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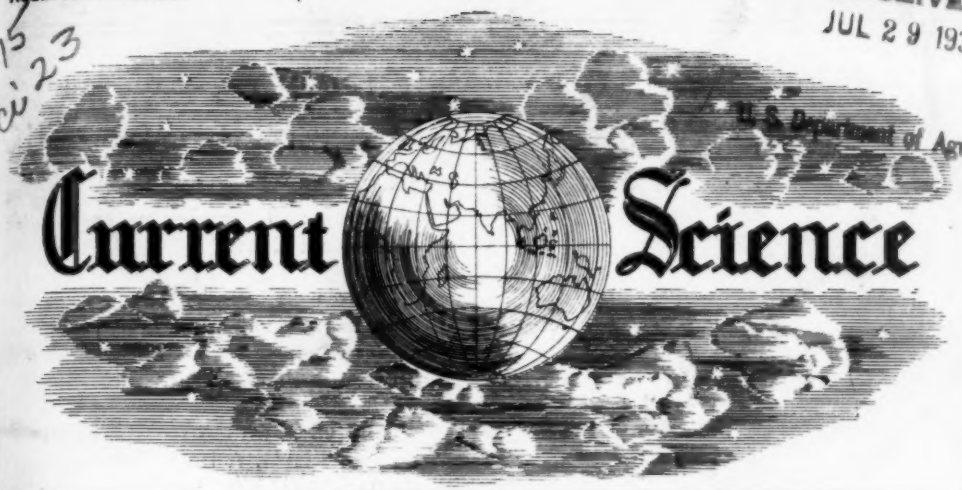

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Current Science

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The Indian Research Council.

THE appointment of the Marquis of Zetland as the Secretary of State for India may be used as an appropriate opportunity for reviving the question of the establishment of the National Council of Scientific Research. His Lordship, during his tenure of office as Governor of Bengal, evinced great solicitude in promoting the cultural advancement of this country, and in April 1933 he caused a circular letter to be issued to a select body of scientists and representative leaders of public opinion in India, offering assistance in case they should agree to co-operate with him in founding an Indian Academy of Sciences and Arts. It may be recalled that almost simultaneously, but independently, *Current Science* in its issue for May 1933 published an editorial in which cogent reasons were put forward for the institution of an Indian Academy of Sciences. Where His Lordship and this Journal contemplated a single authoritative institution, the movement initiated by them resulted in the inauguration of two scientific bodies, *viz.*, The Indian Academy of Sciences and the National Institute of Sciences. Both on grounds of finance and of expediency we deprecate plurality of institutions, and one of our co-operators wrote to us as follows on this subject :

> "The danger, of course, is that if we attempt to establish too many scientific bodies requiring support from Governments and Universities, we make it more difficult for existing institutions to continue : it must be remembered that at present we find it sufficiently difficult to obtain adequate support for the Indian Science Congress and for our journal—*Current Science*."

The existence of multiple scientific bodies of the Academy status must make it increasingly difficult for the Central Government to recognise the claims of any one of these bodies as the official expositor of scientific opinion in India, and must definitely retard all proposals for the establishment of a National Advisory Board of Scientific Research. In this connection, our co-operator from whom we have already quoted, makes the following significant observation :

> "It so happens, however, that some three years ago, a committee of heads of scientific departments of the Government of India was called upon to advise

on the question of the formation of a National Research Council and of National Committees in India to adhere to and co-operate with the International Research Council and its Unions. We expressed the opinion that the formation of such a council was desirable although the conditions were not favourable for the institution of a National Research Council on lines analogous to those followed in most other countries for the reason that there was in India no body comparable to the Royal Society of London, the French Academy of Sciences, etc. The present position is that the project for the formation of a National Research Council in India is in abeyance for lack of funds; but ultimately when the financial situation improves and it becomes possible to consider again the formation of such a Research Council, it will be easier to form such a Council on lines analogous to those existing in other countries, if, in the meanwhile we have formed an Academy of Sciences in India of the nature projected in your (Editor's) circular."

At present we are confronted not so much with financial stringency as with a complicated situation such as few could have visualisedin May 1933, and we are afraid that if it is not promptly and wisely handled, it is capable of postponing indefinitely the establishment of a Research Council in India. For, it is obvious that all the four institutions which claim to occupy the status of an all-India character cannot fulfil the functions which only a strong Central Body can perform. The confidence which such an authoritative institution enjoys will be sufficiently high, as the Marquis of Zetland pointed out in his circular letter, "to consolidate and expand the intellectual interests within its own sphere of influence; while the standard which it maintains must necessarily provide example and inspiration for scientific work of the greatest significance; and the estimation, in which it is held by the International Associations should make its membership to be coveted as a distinction of meritorious and important scientific investigations."

Those who have been following the trend of modern scientific progress in this country must have noticed two distinctive features. The first characteristic is that a close and steady co-operation between different groups of investigators,—medical men, physicists, chemists, biologists and engineers,—is almost indispensable for an adequate solution of all social and economic problems. The second is that scientific discoveries in any one branch of science, whether theoretical or applied, find direct and ready application in apparently unrelated branches of knowledge. We have several research institutions in India equipped and maintained by Government subsidies, and it is obvious that investigations in them should proceed uninterrupted by the fluctuations of financial assistance and the inhibitions of departmental influences. There is therefore a great need for a central agency for the prevention of overlapping of effort and the duplication of expenditure of national revenues. It ought to be one of the functions of such an institution to secure the intimate co-operation of the medical, agricultural, industrial and forest research departments and stress the importance of a clearly defined policy of scientific investigations in these departments for the promotion of the national health and the economic efficiency of the country. It seems to us that the functions of the Research Council should not be restricted to the encouragement of co-ordination of research work alone, however important and necessary it may be for the intellectual advancement of the country. In a sense and perhaps for some time to come, this body must occupy the status and fulfil the functions of the Parliamentary Science Committee in Great Britain. It should seek opportunities for establishing a link between science and Government on the one hand, and on the other, between science and society. It ought to assume the responsibility of promoting discussions in the Council Chambers of Federal India, on scientific subjects in their application to economic policy and national well-being. It may even be necessary and desirable to arrange for occasional addresses by scientific authorities to the principal political parties of Legislative Assemblies and to assist the Government in all measures and acts which involve the application of modern scientific method. The usefulness and importance of the Research Council will, to a large extent, be tested not merely by the scientific prestige to which it might attain, but also by the measure of confidence which it induces in the Central Government on whose bounty it has to depend, and the extent of influence which it exerts on national affairs.

Such a conception of the functions of the representative scientific organisation was recently elaborated by our contemporary

'*Nature*,' and was also emphasised by Sir Mirza M. Ismail in his opening address at the inaugural ceremony of the Indian Academy of Sciences.

This is not, however, the first time that proposals for the formation of the National Council of Research have been put forward. At the first University Conference held in Simla in 1924, Sir C. V. Raman moved the adoption of a resolution for the establishment of a Central Advisory Board of Scientific Research, since the Board of Scientific Advice consisting mainly of the heads of various scientific departments which Government had brought into being was willingly permitted to become defunct in 1920. In September 1930, the Government of India addressed a letter to the Secretary to the Government of Bengal conveying their decision that India should join the International Research Council and its Unions (1) Geodesy and Geophysics, (2) Geography, (3) Astronomy, (4) Biological Sciences, and (5) Radio-Telegraphy, and further stated that provision was made in the budget of the Secretary of State for India for 1930–31 for subscriptions to these bodies. In the same letter Government pointed out that, as they were not aware of the existence of a representative scientific organisation to which adherence to the Council and its Unions could be entrusted, they had arranged for the time being to act as the representative of this country. The annual cost of India joining the Council and the five Unions, calculated on her population basis, is £548–13–4. The Inter-University Board at its conference in 1931 appointed a sub-committee to investigate and report on a scheme for the formation of an Advisory Board of Scientific Research. The Government of Bengal which consulted the Asiatic Society of Bengal on the subject of the letter of the Government of India dated September 1930, received in 1932 a memorandum embodying the considered views of that learned body; and other scientific institutions which were also consulted, submitted by that date their replies, generally favouring the establishment of a Research Council in India. It seems to us that the Indian Research Council when it is formed must be the only scientific organisation which by its representative character and prestige could be entrusted with the responsibility of adhering to the International Research Council and its Unions. It is not financial stringency that now stands in the way of creating this body so much as the confusion produced by the multiplicity of scientific institutions which within a year have come into existence. The Government of India were looking forward, as is manifest from their letter of September 1930, to the foundation of a strong and authoritative scientific organisation which would be willing and competent to advise them on the formation of the Indian Research Council. The position in 1935 is not more hopeful than it was in 1930 and so long as scientists in India permit the existing state of affairs to continue, the Government of India will also continue so long to remain in a state of perplexity. A definite movement should be initiated to remove the anomaly of four scientific bodies, each trying to function as an All-India organisation, and claiming to represent the national scientific interests. We could put forward a scheme for an All-India Organisation which would be thoroughly representative and satisfactory, if there were any indication that the conditions were propitious.

The value and usefulness of the proposed Indian Research Council must naturally depend not only on the readiness of the Government of India to utilise its services and to support it financially, but also on the willingness and preparedness of Indian Scientists to co-operate with one another, and with governments and their scientific departments. The spirit of exclusiveness and the provincial outlook, which unfortunately overtake scientific achievements only too often in India, must be fatal to the growth of public institutions and to the creation of expert scientific opinion, capable of influencing the policies and projects of Government. It is true that almost all the practical problems of administration involve scientific factors, and it is equally true that the absence of a representative organisation, which could provide Governments with a reasonably adequate unanimity of expert opinion on the control and administration of the life of the community, must account for much useless expenditure of public revenues. If the scientists would show any disposition to set their house in order and also their willingness to reach agreed settlement in matters relating to their departments, then the Government of India may be expected to appreciate the value and need of advice from those who by their foresight, character and capabilities acquire a right to be consulted. The one essential factor for the establishment of the

Indian Research Council is a modification of the existing policy, spirit and outlook of public scientific bodies, which must merge into a single representative organisation, so as to command the esteem and confidence of Governments, Universities and the general public.

The new Secretary of State for India who, as Governor of Bengal, had, more than any other administrator, evinced the greatest practical concern in the promotion of the cultural life of this country, and whose interest in the scientific progress of its people had never abated even in the midst of his other pre-occupations, may be expected to use his rare influence in establishing a right relationship between science and Indian administrative problems. Professor F. O. Bower once acknowledged that it was owing to the energy and enthusiasm of Lord Balfour that science was welcomed into the inner circle of Imperial Administration; and India may confidently hope that the critical and constructive mind of the Marquis of Zetland may formulate a plan which would ensure a reasonable appreciation of the value of science in the administrative departments of the Government of India. We hope that an atmosphere favourable for initiating a movement for the establishment of the Indian Research Council will soon be produced by scientists in India who, by reason of their knowledge and capabilities, are entitled to exercise a greater control over such administrative problems of the country as fall within the range of scientific influence. These problems should no longer be permitted to be entrusted to the hands of those who have no first-hand knowledge of science, and the first step in this direction is to remove the reproach that India is practically the only civilised country without a National Research Council, to which the Government of India could look up for advice and guidance in all practical measures affecting the moral and material advancement of the people.

The Educational Advisory Board.

IN 1923 the Government of India abolished the Bureau of Education as a measure of retrenchment and the Hartog Committee deplored this act of Government in order to save a few thousand rupees. When a few months back Sir G. S. Bajpai referred in the Legislative Assembly to the intention of Government to revive the Central Advisory Board of Education in accordance with the recommendation of the Committee, the Assembly suggested postponement of the proposals in view of the forthcoming reforms in the provincial and central administration. If the proposed Advisory Board is to fit into the general framework of federal administration, it is obvious that the Indian States should be adequately represented, for education, which is at the basis of all progress, must always remain as an all-India subject. The Hartog Committee points out that education as a provincial transferred subject has during the past fifteen years made little progress especially in the field of free and compulsory elementary education. The Simon Commission, of which the Committee was an auxiliary body, viewed the problem of education as one concerning the entire political and social destiny of the Indian Empire and the question of the extension of franchise and that of the reconstruction of rural life depend largely upon the amount of benefit which a carefully devised scheme of higher elementary education confers on the general Indian population.

The value and usefulness of the Board do not depend so much on its prestige as on the amount of expert knowledge, experience and industry which its members will ultimately bring to bear on the problems entrusted to them for investigation and advice. The existence of the Board consisting of eminent educationists and representatives of public opinion can be justified if Government recognises the need for advice and provides adequate funds for giving effect to its recommendations. Proposals for the rapid extension and improvement of the educational schemes in India are frequently made in the Legislative Chambers and Governments have frequently pleaded inability to accept the proposals of people's representatives on account of the limited provision they could make for education in their annual budget. The realisation that money spent on people's education is in the nature of public investment, must be the foundation of the financial policy of Government, whose first and last line of defence must at all times be a contented, prosperous and homogeneous population.

The Quetta Earthquake.

THE disaster which has overwhelmed Quetta staggers imagination. Those who are situated far from the scene of this appalling catastrophe may not be able to comprehend the straits to which this frontier military station has been reduced by the earthquake. We have great praise for the military authorities for arranging efficient and prompt salvage and relief operations, and the splendid manner in which response is forthcoming to the Viceroy's appeal for funds is a witness to the profound and universal sympathy evoked by this holocaust. It is unofficially stated that there must be a death roll of 65,000 people.

Premonitions of the coming disaster were not wanting. Since the earthquake which convulsed Bihar last year, earth tremors were reported from various places and they were continually travelling westward. It is now well known that practically all Indian earthquakes have originated from the peripheral tracts of the Indo-Gangetic plain, at the foot of the great Himalayan mountain system. This belt of country is a zone of weakness and strain in the underground rocks, due to the severe folding and crumpling to which they have been subjected in the process of the elevation of the Himalayas. Now and again in some place or other along this belt, where the pressure exceeds a certain limit, the rocks readjust themselves and every such readjustment is accompanied by an earthquake of smaller or greater intensity.

The recent disaster which shattered Quetta is an example of such a tectonic earthquake. The underground geological structure of the rocks in the country affected by the upheaval is to a certain extent indicated by the nature and disposition of the hill ranges in the area. Geologists have pointed out that the several mountains of Baluchistan belong to the same system as the main mass of the Himalayas, and they really form a part of one great family of mountain chains. A glance at the physical map of Baluchistan shows that the Sulaiman range forms an important line of hills running north and south. At its southward end, the range takes a western bend forming the Bugti hills, and then it soon turns northwest giving rise to the Marri hills, extending along the Bolan pass to as far as Quetta. At this point there is a sharp hairpin bend in the alignment of the hill ranges and we have, to the south of Quetta, the Brahui and the Kirthar mountains running due north and south. In a region of compression like the area covered by this plexus of hill ranges showing abrupt flexures and lying under severe strain, any increased stress must naturally result in a severe convulsion of the earth's surface. To the east of the present scene is the great Kachhi plain where an earthquake of great magnitude took place in 1909. The belt of the greatest havoc in the case of the recent earthquake runs roughly north and south extending over an area of about 70 miles long and 16 miles broad, including important and populous towns such as Quetta and Mastung. This will give us an idea of the epicentral area, where rocks of varying degrees of hardness and of different ages are known to occur, constituting the Baluchistan Mountain System. It is well known that "faulting" in rocks is the commonest type of movement which gives rise to earthquakes, and the probability is that it is a dislocation of this type that has been responsible for the Quetta Earthquake.

A more definite diagnosis of the cause of this earthquake must await a thorough and detailed geological investigation which has already been initiated by the Geological Survey of India.

Within recent times earthquakes have become an epidemic, and places like Quetta, one of the foremost R. A. F. base headquarters of the Western Command, where there must necessarily be large ammunition depots, need special protection.

Transmutation of Elements and Induced Radio-Activity.

By T. S. Subbaraya, M.Sc., A.Inst.P.

THE alchemists of old had only dreamed of one artificial transmutation, *viz.*, that of the baser metals into gold. But modern Physics has witnessed wonderful transmutations far beyond the vision of the most visionary alchemist. The last year in particular has brought forth such a wealth of new and astounding results that to-day, we have already great difficulty in giving a resumé in a few pages. New discoveries are being published in ever-increasing numbers so that it behoves us to take stock of our position at frequent intervals. Such a survey is particularly needed at present and the following pages will be devoted to a brief account of the most important results so far obtained.

The first artificial transmutation was achieved by Rutherford in 1919 when he bombarded nitrogen by α-particles and showed that hydrogen was produced. Blackett's cloud track photographs of this phenomenon showed that the α-particle entered the nitrogen nucleus, ejecting a proton and forming an O^{17} nucleus. The new missiles placed at the disposal of science by the discoveries of Cockcroft and Walton, Chadwick, Lawrence and Urey have rendered possible a large variety of transmutations. Our present purpose is not to discuss the results of all these experiments, but to pass on to a new discovery made by Curie and Joliot in the course of their researches in this field. We mean the production and study of new radioactive elements and the consequent enrichment of our knowledge of the nucleus. This new discovery is not only most important and interesting in itself but also because it has made it possible to produce chemical proofs of transmutation where previously one had to content oneself with considerations of the total charge and mass of the particles involved in the process and the conclusions deducible by such considerations.

The discovery of new radioactive elements was made by Curie and Joliot in the course of their investigations of the result of bombarding nuclei of the light elements by α-particles from Polonium. The experiments of Rutherford and others had showed that most of the light nuclei up to Potassium emitted protons when bombarded by α-rays, resulting in the formation of nuclei of other known elements. Now Curie and Joliot found that fluorine, sodium and aluminium also emitted neutrons when thus bombarded. Here therefore were new transmutations which could not however be explained so easily as the previous type. Thus taking the case of aluminium, we have the following equation representing the transmutation by emission of protons :

$$^{27}_{13}\mathrm{Al} + ^{4}_{2}\mathrm{He} \rightarrow ^{30}_{14}\mathrm{Si} + ^{1}_{1}\mathrm{H} \quad .. \quad (1)$$

In these equations, the lower index represents the charge on the nucleus and the upper index gives its mass. The equation is such that the sums of the charges on either side balance as also the sums of the masses. Thus in the above equation, the total charge on the left is $15=13+2$, and so also on the right the sum is $15=14+1$. Similarly the mass on the left is $27+4=31$ while that on the right is equally $31=30+1$. The symbol $^{1}_{1}\mathrm{H}$ represents the proton that is ejected during the transformation. When we try to set up a similar equation for the transmutation observed by Curie and Joliot in which neutrons were ejected, we are led to the following :

$$^{27}_{13}\mathrm{Al} + ^{4}_{2}\mathrm{He} \rightarrow ^{30}_{15}\mathrm{P} + ^{1}_{0}n \quad .. \quad (2)$$

The symbol $^{1}_{0}n$ represents the ejected neutron of charge zero and mass one. The nucleus of Phosphorus of charge 15 and mass 30 which we are thus led to postulate is one which does not occur ordinarily in Nature. Hence the difficulty involved in the above explanation. This very difficulty led to important discoveries as we shall see below.

Now Curie and Joliot had already found[1] that some light elements like beryllium, boron and aluminium emit positrons when bombarded by α-particles from Polonium. In the case of beryllium they considered that the positrons were due to a materialization of the γ-rays emitted by beryllium along with neutrons, thus :

$$^{9}_{4}\mathrm{Be} + ^{4}_{2}\mathrm{He} \rightarrow ^{12}_{6}\mathrm{C} + ^{1}_{0}n + \epsilon^{+} + \epsilon^{-} \quad .. \quad (3)$$

The symbols ϵ^{+} and ϵ^{-} represent the positive and negative electron respectively. The

[1] *Comptes Rendus*, 1933, **196**, 1885.

view represented by equation (3) was supported by a comparison of the energies of the positrons emitted and of the γ-rays usually accompanying the emission of neutrons by beryllium. In the case of boron and aluminium, however, they found that the positrons had to be attributed to the product which resulted from the transmutation with the ejection of neutrons. The discovery of new radioactive elements and the explanation of (2) followed at once when Curie and Joliot found[2] that the emission of positrons continued even after they had removed the source of bombarding α-rays, and that the activity, *i.e.*, rate of emission of positrons, followed an exponential law of decay as in the case of ordinary radioactivity. The explanation of (2) is now clear. We have seen that the transformation leading to the emission of neutrons necessitates the assumption of the formation of hitherto unknown nuclei such as $^{30}_{15}P$. If we now assume that these nuclei are ordinarily not found because they are unstable and that they disintegrate with the emission of positrons according to the ordinary law of radioactive decay, we have an explanation of the phenomena observed by Curie and Joliot. They also observed that the decay of each of the new nuclei produced by them had a characteristic half-value period. Thus in the case of aluminium, boron and magnesium, the half-value periods were respectively 3 mins. 15 secs., 14 mins., and 2 mins. 30 secs. The nuclear reaction as envisaged by Curie and Joliot in each of these cases is as follows :

$$^{27}_{13}Al + ^{4}_{2}He \rightarrow ^{30}_{15}P + ^{1}_{0}n; \quad ^{30}_{15}P \rightarrow ^{30}_{14}Si + \epsilon^{+} \quad (4)$$

$$^{10}_{5}B + ^{4}_{2}He \rightarrow ^{13}_{7}N + ^{1}_{0}n; \quad ^{13}_{7}N \rightarrow ^{13}_{6}C + \epsilon^{+} \quad (5)$$

$$^{24}_{12}Mg + ^{4}_{2}He \rightarrow ^{27}_{14}Si + ^{1}_{0}n; \quad ^{27}_{14}Si \rightarrow ^{27}_{13}Al + \epsilon^{+} \quad (6)$$

The new radioactive elements thus produced were called radio-phosphorus, radio-nitrogen and radio-silicon respectively. Not content with a mere guess at the nature of the radioactive products thus formed, Curie and Joliot proceeded to establish their identity by chemical tests. This they were able to do, thanks to the radioactivity of the new elements. In all previous experiments on artificial transmutation, the chemical nature of the product could not be established because of the extremely minute quantity of the substance produced ; in fact the product consisted of a small number of atoms and no chemical tests could be carried out on these. But the situation was now different ; although the new radioactive products were also present in equally minute quantities, their radioactivity was there to serve as an indicator. Thus if the new products were precipitated by any chemical reaction, the fact of their having been so precipitated could be established by the circumstance that the radioactivity was now associated with the precipitate. In this way the chemical tests for phosphorus and nitrogen were applied and their formation in the processes represented by (4) and (5) was thus proved. Thus for the first time, new radioactive elements were produced and their nature securely established by chemical tests.

Other workers were not slow to pursue these investigations with various modifications. L. Meitner[3] studied the reactions occurring when aluminium was bombarded by α-rays from Polonium and by means of Wilson cloud chamber photographs showed that aluminium is transformed in two ways as follows :

$$^{27}_{13}Al + ^{4}_{2}He \rightarrow ^{30}_{14}Si + ^{1}_{1}H \quad .. \quad (1a)$$

and

$$^{27}_{13}Al + ^{4}_{2}He \rightarrow ^{30}_{14}Si + ^{1}_{0}n + \epsilon^{+} \quad .. \quad (2a)$$

She also showed that the first of these reactions takes place about four times as frequently as the second. This fact that aluminium disintegrates in two ways was utilised by Curie and Joliot to arrive at an estimate of the mass of the Neutron. A comparison of the above equations shows that if the energies of the proton and of the neutron and positron appearing on the right-hand side of (1*a*) and (2*a*) respectively are known, an accurate estimate of the mass of the neutron becomes possible without the necessity of accurately knowing the masses of the other nuclei taking part in the reaction. Thus if m_p and m_{ϵ^+} are the masses of the proton and positron respectively, and W_p, W_n, W_{ϵ^+}, W_R and $W_{R'}$ represent the kinetic energies of the proton, neutron, positron and the recoiling silicon nucleus in (1*a*) and (2*a*) respectively, the

[2] *Comptes Rendus*, 1934, **198**, 254 & 559.

[3] *Naturwiss.*, 1934, **22**, 172.

mass of the neutron

$$= m_p - m_{\epsilon^+} + W_p - W_n - W_{\epsilon^+} + W_R - W_{R'}.$$

The mass of the neutron was in this way found to be 1·0092. This is higher than Chadwick's original value 1·0067 and even his revised value, *viz.*, 1·0080 is less than the value thus deduced by Curie and Joliot. The question of the mass of these particles is important since it helps to throw light on the question as to which particle is elementary and which composite. Recently, Wentzel[4] has shown reasons to believe that the neutron may have a mass equal to that of the hydrogen atom; we shall, however, not linger over this topic here.

A comparison of equations (1*a*) and (2*a*) further shows that since in (1*a*) we have one particle of spin $\frac{1}{2}\frac{h}{2\pi}$ emitted while in (2*a*) there are two particles each with a spin of $\frac{1}{2}\frac{h}{2\pi}$, we have, in order to satisfy the conservation of angular momentum, to assume that in (1*a*) another particle of negligible energy, but with a spin of $\frac{1}{2}\frac{h}{2\pi}$ is emitted. This hypothetical particle has been called an anti-neutrino just as the similar particle assumed by Fermi to be emitted during β-transformations was called a neutrino. On de Broglie's theory a neutrino and an anti-neutrino together constitute a photon of light. These questions however cannot be elaborated here.

Ellis and Henderson[5] repeated the experiments of Curie and Joliot and confirmed their results. Cockroft, Gilbert and Walton[6] have employed artificially accelerated protons as missiles to produce new radioactive elements, while McHenderson, Livingston and Lawrence[7] and Crane and Lauritsen[8] have used artificially accelerated deutons and protons and produced other new radioactive bodies. A number of these emit positrons together with γ-rays due to their annihilation. Even more interesting is the work of Fermi[9] and his collaborators. Whereas the charged missiles such as protons, deutons and α-particles employed by previous workers could be directed against light nuclei only since the greater charge on heavier nuclei prevents these charged missiles from hitting the nucleus, Fermi hit upon the idea of employing neutrons to bombard various nuclei. These neutrons, being uncharged, can penetrate even the heaviest nuclei and systematic work by Fermi and his collaborators has resulted in the production of new radioactive elements from almost all the elements of the periodic table including Uranium. In most of these cases, a β-activity with the emission of electrons is observed. In some cases, the neutron enters the struck nucleus forming a heavier isotope of the same. Apart from the regularities which these authors have pointed out, great interest attaches to their claim to have produced elements of atomic numbers 93 and 94. In most cases, they have established the nature of the radioactive products by chemical methods, but in the case of elements 93 and 94, their conclusions were called in question by A. v. Grosse. They found that when Uranium is bombarded by neutrons, new radioactive products of half-value periods, 13 mins. and 100 mins. were produced. Chemical tests were made to assure themselves that the new products were not isotopes of known elements. Grosse[10] however came to the conclusion that the chemical reactions observed with the new products were characteristic of element number 91 (Protactinium) and that the reactions which were supposed by Fermi to be opposed to such a conclusion were not conclusive at all. In view, however, of the importance of the claim put forward by Fermi, L. Meitner[11] has repeated their experiments and by a new and decisive chemical technique established beyond doubt that the new bodies are not elements of atomic number less than 92 and that the product of period 13 mins. is most probably element No. 93; and since her experiments show that the 100 mins. product is not an isotope of the 13 mins. product, the longer-lived product must be element No. 94. Whether the new elements beyond Uranium thus proved to exist are similar to Rhenium and Osmium or whether they belong to a family similar to the rare earths, is a question which is awaiting solution.

The discovery of Curie and Joliot has thus led to important results which are sure to increase our knowledge of nuclei and

4 *Naturwiss.*, 1935, **23**, 35.
5 *Proc. Roy. Soc.*, A, 1934, **146**, 206.
6 *Nature*, 1934, **133**, 328.
7 *Phys. Rev.*, 1934, **45**, 428.
8 *Phys. Rev.*, 1934, **45**, 431 and 497.
9 *Proc. Roy. Soc.* A, 1934, **146**, 483.
10 *Nature*, 1934, **134**, 773.
11 *Naturwiss.*, 1935, **23**, 37.

atoms; we must, however, before closing, refer to the practical utility of their discovery which Curie and Joliot have pointed out.[12] The new artificially produced radioactive elements and their radiations may in the near future displace the costly radium for therapeutic purposes, and minute traces of these radioactive bodies may be utilised as indicators in studying biological processes. Both of these happy ideas promise to produce lasting good to humanity and we may be confident that the important discoveries of Curie and Joliot will be followed up and lead to advances of vital importance in times shortly to come.

Baluchistan Earthquake of May 31, 1935.

By Dr. S. C. Roy, M.Sc. (Cal.), D.Sc. (Lond.),
Colaba Observatory, Bombay.

BARELY seventeen months have passed since the occurrence of the disastrous earthquake in Bihar and Nepal, and India is again sorely stricken by another calamitous earthquake in Baluchistan. The present note gives such preliminary information regarding the focal region and the intensity of the Baluchistan earthquake as can be gathered from the records of the Colaba Observatory alone.

Colaba Milne-Shaw seismograms of the Baluchistan earthquake are reproduced in Fig. 1 (N-S component) and Fig. 2 (E-W component). The preliminary and the

Fig. 1.
Colaba Seismogram of Baluchistan Earthquake, May 31, 1935. Milne-Shaw North-South.

[12] *Radioactivité Artificielle*, Hermann et Cie, Paris, 1935.

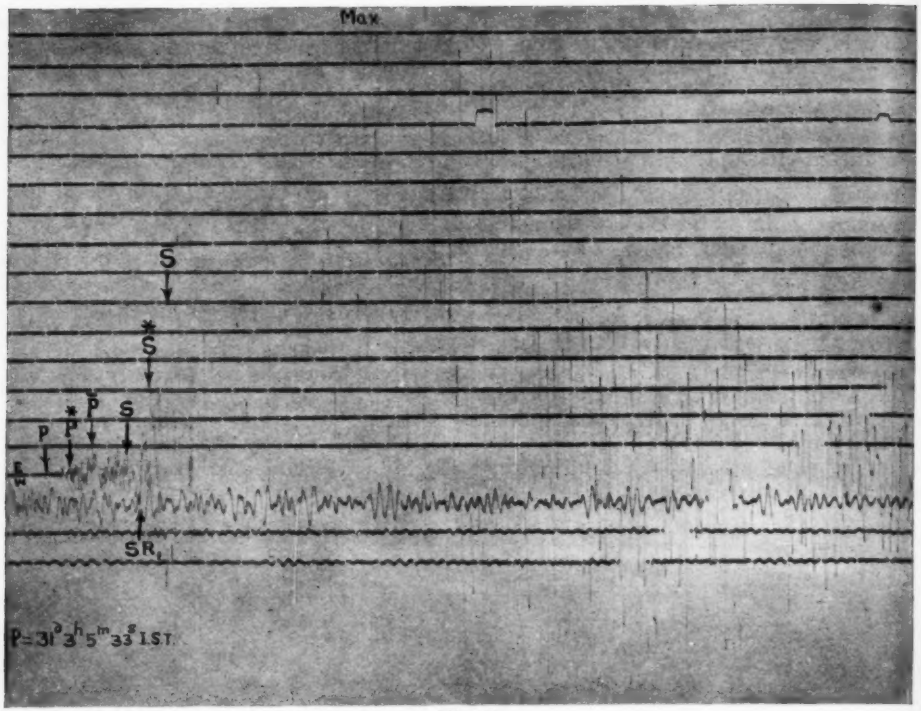

Fig. 2.

Colaba Seismogram of Baluchistan Earthquake, May 31, 1935. Milne-Shaw East-West.

secondary waves of shocks originating in the upper layer or crust of the earth travel to a near station in three distinct paths. The six phases P, $\overset{*}{P}$, $\overline{P}$, S, $\overset{*}{S}$ and $\overline{S}$ appear to be identifiable on the Colaba seismograms of the Baluchistan earthquake as in the case of the North Bihar earthquake.[1] The development of destructive surface waves also supports that the focal region of the Baluchistan shock was shallow in depth. An estimate of the actual depth can be made only when it is possible to scrutinise and study the records from other Indian seismic stations. The S-P interval at Colaba is 2 mts. 21 secs. giving an epicentral distance of about 1300 kms. The first preliminary tremors begin with an impetus of $5 \cdot 2\ \mu$ towards south and $2 \cdot 3\ \mu$ towards east giving the direction of the focal region as 333°. These data would locate the focal region of the earthquake roughly about 40 kilometers to the south of Quetta. The origin time of the shock is calculated to be 3 hrs. 2 mts. 43 secs. I.S.T.

An estimate of the energy of the Baluchistan earthquake can be made from the Colaba seismic records by using a formula given by Dr. Harold Jeffreys.[2] While calculating the energy of the Pamir Earthquake of February 18, 1911, Dr. Jeffreys has shown that the major part of the energy of an earthquake is carried by the Rayleigh waves, the contribution from the longitudinal and the distortional waves being only a few per cent. of the contribution by the long waves. Energy in a Rayleigh wave is the same as if there were no vertical motion and the horizontal motion had the same amplitude as at the surface down to a depth $H = 1 \cdot 12\ \lambda$, where λ is the wave-length. The total energy crossing a small circle at distance Δ from the origin is

$$E = 8\pi^3 R \sin\Delta \rho \int \frac{a^2 HV}{T^2} dt$$

[1] *Curr. Sci.*, May 1934, **2**, 419; and Jan. 1935, **3**, 298.

[2] *M. N. Geo.-Suppl.*, January 1929, **1**, 22–31.

where R = Radius of the earth.
Δ = Epicentral distance in degrees of arc.
ρ = Density of the earth's crust.
a = Amplitude of the earth's horizontal motion.
T = Period of the long wave.
and V = Velocity of propagation of long waves.

Now taking

$R = 6 \cdot 4 \times 10^8$ cms. ; $\rho = 3 \cdot 0$ gm./cm.^{3}

and $V = 3 \cdot 0 \times 10^5$ cm./sec.

we have

$$E = 4 \cdot 3 \times 10^{17} \sin\Delta \times \int \frac{a^2 H}{T^2} dt.$$

The average value of T at Colaba for the Baluchistan earthquake is about 12 s. and taking the average velocity of long waves as 3 km./sec. we find that $H = 4 \times 10^6$ cms. Also from the seismograms the value of $\int \frac{a^2\, dt}{T^2}$ is 0·02 cm.^{2}/sec. The energy of the Baluchistan earthquake thus works out to be about 7×10^{21} ergs. The Colaba records of the North Bihar earthquake of January 15, 1934, were not satisfactory but a rough estimate for that shock gives the value of $\int \frac{a^2\, dt}{T^2}$ near about 0·2 cm^2./sec., leading to the approximate value of 7×10^{22} ergs for its energy. Bihar earthquake was therefore about 10 times more energetic than the Baluchistan earthquake. This conclusion is also supported by the fact that the maximum amplitude of earth's motion at Colaba was greater than 1300 μ in the case of the Bihar earthquake while it is only about 400 μ for the Baluchistan shock. But the most unfortunate thing about the Baluchistan earthquake has been its occurrence during the early hours of the morning with consequent heavy death-roll.

The Progress of Work in India on the Embryology of Angiosperms.

By Dr. P. Maheshwari, D.Sc.,
Agra College, Agra.

INVESTIGATIONS on this subject started in this country only about fifteen years ago, but the number of annual contributions since then has been steadily increasing. The purpose of this article is to give a brief review of this work and to consider, if possible, some of the lines of research that may be most profitably undertaken in future by students of embryology in this country. Some judgment has been exercised in the selection of papers and a few investigations dealing with purely cytological studies have been left out, but otherwise the review is complete, and as far as the writer is aware, no important papers have been omitted.

The first observations of this kind were published from Allahabad by Kenoyer[1] (1919) who, while describing the dimorphic carpellate flowers in *Acalypha indica* L., noted the obturator, the beak-like tip of the nucellus and a few stages in the development of the embryo sac, which were, however, quite insufficient to permit definite conclusions.

Dastur[2] (1922) in an investigation of *Hydnora africana* Thumb., an interesting parasite, material of which had been collected from South Africa, writes that the ovules are orthotropous and have a single integument. The megaspore mother cell is hypodermal and directly gives rise to an 8-nucleate embryo sac of the Lilium-type. The most noteworthy fact is that the proembryo consists of a long chain of cells, of which the middle region gives rise to the embryo proper. These observations are of great interest, but it must be pointed out that the material was probably insufficient for a critical investigation and, as Schnarf[24] (1931) has pointed out, the statements need confirmation.

Tiwary[3] (1926), from Benares, made the interesting discovery of polyembryony in *Eugenia jambolana*, the extra embryos arising from the position of the egg apparatus or from the nucellus. It is also stated the original embryo sac sometimes becomes pressed out and obliterated, while some of the nucellar cells appear to be on their way to form embryo sacs. It may be mentioned here that recently Pijl[23] (1934) has published the results of a detailed study of polyembryony in several spp. of *Eugenia* and his observations differ in some respects from those of Tiwary.

Tiwary and Rao[4] (1934) have traced the development of the embryo sac in another member of the Myrtaceæ, *Callistemon linearis*,

which follows the normal course laid down for angiosperms.

From the same laboratory, Joshi[5] (1933) made a few observations on megaspore and embryo sac formation in *Argemone mexicana* L., and these were supplemented by Bose and Banerji.[4] The development is perfectly normal, but the antipodal cells attain a specially large size. Joshi's statement that endosperm formation may begin even before fertilisation needs more critical study.

Joshi and Raman Rao[7] (1934) made some very interesting observations on the embryology of *Tinospora cordifolia* Miers. The development of the embryo sac is quite normal, but there is no fertilisation and all the nuclei except the polars are said to degenerate. Endosperm formation continues, but no embryos could be seen even in mature seeds. These observations were immediately subjected to comments and criticisms (Sahni,[7] Tiwary[7]) and the presence of seeds with normal embryos has now been reported from Agra (Singh[7]), Bangalore (Seshagiriah[7]) and Ahmedabad (Ajrekar and Oza[7]). Cases of parthenocarpic fruits *are* on record and a condition as described by Joshi and Raman Rao is entirely possible, but as suggested by Singh it is more likely that in the present case the egg does not degenerate but develops parthenogenetically. Further observations on the embryogeny of this plant will be awaited with interest.

Joshi and Venkateswarlu[8] (1933) call attention to the peculiar behaviour of the synergids in *Ammania baccifera* L. The embryo sac develops in the usual way, but the synergids are persistent and begin to enlarge. Their nuclei divide amitotically, the lateral walls dissolve and the two cells fuse to form a "syn-synergid", which persists like a multi-nucleate collar round the suspensor of the growing embryo.

Naithani[9] (1933) from Allahabad, working on the life-history of *Digera arvensis* Forsk., found that the pollen grains are 3-nucleate at the time of shedding, and the megaspore mother cell gives rise to a row of 3 cells, of which the chalazal produces the embryo sac. A few months later Joshi and V. Rao[10] published a more detailed account of the same plant. The pollen grains are reported by them to be usually bi-nucleate and some variations have been recorded in megasporogenesis. It has been stated that 2, 3 or 4 megaspores may be formed and some other interpretations have also been offered, that are now shown to be incorrect by Puri and Singh.[11]

At Calcutta a large amount of work in this line is being done by Banerji and his students. Agharkar and Banerji[12] (1930) investigated the development of the embryo sac in *Carica papaya* and found that a normal linear tetrad is formed and as usual the chalazal megaspore gives rise to an octonucleate embryo sac with ephemeral antipodals. It must be pointed out that according to Heilborn* (1921, 1928) all the 4 megaspore nuclei (unseparated by walls) take part in the development and usually only one of them divides again, resulting in a 5-nucleate embryo sac. In view of the differences between these observations and those of previous authors like Kratzer* (1918) and Usteri* (1907), it seems profitable to reinvestigate the plant using material from as many different sources as possible. A feature which deserves further attention is the frequent formation of fruits even without male plants in the vicinity and the occasional presence of parthenocarpy.

Banerji's[13] work on the life-history of jute (*Corchorus olitorius* and *C. capsularis*) is a welcome addition to our knowledge of the Tiliaceæ. It is remarkable that even in an annual plant like this, growing in a tropical climate, the first division of the egg occurs 12–16 days after pollination. The same author has also studied the development of the female gametophyte of *Colocasia antiquorum* Schott.,[4] with a view to discover the causes of sterility in this plant. It was found that although degenerations start as early as the megaspore mother cell stage they are most common after the megaspores have been formed and sections of open flowers invariably show crumpled ovules without any embryo sacs.

Banerji and Bhaduri[14] (1933) have recorded the presence of false polyembryony in *Nicotiana plumbaginifolia* and also found some early stages of nucellar embryony in *Petunia* and *Withania*. Bhaduri[13] (1932) has given a detailed account of the life-history of *Solanum melongena* and another paper dealing with several other members of the family belonging to the genera *Solanum*, *Physalis*, *Withania*, *Datura*, *Cestrum*, *Nicotiana*, *Petunia*, *Salpiglossis* and *Brunfelsia*, is in the press. The same author has also observed an interesting peculiarity [first noticed by Miss Ferguson* (1927) in *Petunia*] in a tomato strain grown in the experimental grounds of the Calcutta University. It is

stated that the fusion nucleus divides, before the opening of the flower, to form a small micropylar and a large chalazal chamber. After the discharge of the pollen tube, one of the male nuclei fuses with the egg and the other with the endosperm nucleus in the micropylar chamber. This results in the formation of two types of endosperm cells, some with the triploid number (derived from the micropylar cell) and others with the diploid number (derived from the unfertilised chalazal cell).

From the same laboratory, Roy[15] (on *Pachyrhizus*, *Cajanus*, *Dolichos*, *Pisum* and *Lathyrus*), Datta[10] (on *Cassia tora*) and Pal† (on *Tamarindus indica*) have made valuable additions to our knowledge of the Leguminosæ. The statement that in all the plants mentioned above(except *Lathyrus*), no parietal cell is cut off and the archesporial cell differentiates in the third layer of the nucellus, needs more critical observation. It seems more likely that it is actually hypodermal as in the other members of the family, but becomes clearly distinguishable only after having cut off a wall cell and attained an appreciable increase in size (see remarks by Singh and Shivapuri[11], p. 429). S. Datta[5] has made some interesting observations on the embryogeny of two spp. of *Nolana*.

At Bangalore, Dr. M. A. Sampathkumaran has given a great impetus to such work. Rao[14] (1932) in a preliminary note on *Balanophora indica* states that the development of the embryo sac in this plant resembles *B. globosa* described by Lotsy* (1899). It must be mentioned here that very recently Ekambaram and Panje[11] from Madras have published their observations on a sp. of *Balanophora* collected from the Coorg-Malabar forests. Unlike other spp. of this genus, investigated by Treub* (1898) and Ernst* (1914), this one seems to have a normal sexual cycle with an embryo sac arising from the micropylar megaspore of a tetrad and with strong evidence of fertilisation. The female gametophyte is U-shaped with 4 nuclei in each end, but those destined to form the antipodals and the lower polar nucleus fuse among themselves to form a large irregular nucleus. The endosperm arises from the upper polar nucleus and the fertilised egg divides longitudinally.

Seshagiriah (1932[14], 1934[7]) has made some very interesting observations on the life-history of *Zeuxine sulcata* Lindley, a marsh orchid. Degenerations are found to be of frequent occurrence in the anthers and the second reduction division is entirely suppressed, resulting in the formation of "dyads of microspores". The nucleus in these cells divides to form the tube and generative nuclei, but the pollen grains soon degenerate. In some pollinia the heterotypic division was found to show certain abnormalities in the presence of several spindles which result in the formation of supernumerary nuclei, but none of these is functional. The megaspore mother cell undergoes the usual reduction divisions and forms a linear tetrad of megaspores. A peculiar feature is that all four cells of the tetrad directly function to form an embryo and additional embryos arise from divisions of some nucellar cells. In a friendly letter to the writer, the author states that an actual reduction of chromosomes is accomplished during the formation of megaspores and both nucellar and megasporic embryos persist in mature seeds.

From the same laboratory Narasimha Murthy[17] (1933), working on *Limnophyton obtusifolium* Miq., finds 3-nucleate pollen grains with two male cells, an 8-nucleate embryo sac developing according to the "Scilla-type" and a delayed triple fusion. The same author has also studied the life-history of *Ottelia alismoides*,[7] which is similar to other members of the Hydrocharitaceæ, except in having 2-nucleate pollen grains and a hypodermal archesporial cell which is said to function directly as the megaspore mother cell. Another feature of interest is that sometimes the microspores form linear tetrads in addition to the usual isobilateral type.

Rangasamy[10] (1934) has worked out the life-history of *Vallisneria spiralis*, but this investigation seems to have been carried out in ignorance of the previous studies of Burr* (1903) and Wylie* (1923) on this species.

Laksminarasimha Murthy[7] (1934) has studied the life-history of four members of the Commelinaceæ: *Cyanotis cristata*, *Cyanotis axillaris*, *Aneilema spiratum* and *Zebrina pendula*. The presence of needle-like crystals and mitotic divisions in the tapetal periplasmodium is of interest. After fertilisation, the narrow antipodal end of the embryo sac pierces deep down into the nucellus like a haustorium. The young embryo is merely a spherical mass of cells corresponding to the "Pistia-type" among monocotyledons.

Srinath[7] (1934) reports the usual type of embryo sac in *Herpestris monniera*, characterised by an absence of wall cells and the

formation of an integumentary tapetum, as is general among the Sympetalæ. The first division of the primary endosperm nucleus is followed by a transverse wall, separating the embryo sac into two chambers. The nucleus of the chalazal chamber divides only once and this part develops directly into a 2-nucleate chalazal haustorium. The micropylar chamber gives rise to all of the endosperm and a micropylar haustorium composed of four uni-nucleate lobes.

Kausik[7] (1935) has investigated the life-history of *Utricularia coerulea* L. The development is essentially similar to that described by Wylie and Yocom* (1923) in *U. vulgaris*. In both spp. the fertilised egg sends in a tubular prolongation, and the endosperm gives rise to both micropylar and chalazal haustoria, which take an active part in the absorption of food material.

The Rutaceæ is perhaps the first family in which polyembryony was discovered and Chakravarthy[7] (1935) has added *Murraya koenigi* to the list. The supernumerary embryos, which are derived from the adjoining nucellar cells, are usually distinguishable from the egg-embryo by the absence of a suspensor in the former. Most of them get arrested in their development and only 2 or 3 form cotyledons.

From Agra, a number of papers have been published by Maheshwari and his students. Johri[18] has investigated the life-history of *Limnophyton obtusifolium* and the chief difference between his results and those of Narasimha Murthy is that according to the former most of the embryo sacs are only 6-nucleate (the latter author found them to be 8-nucleate), as the two chalazal nuclei usually do not divide after the 4-nucleate stage. He has also reported a similar behaviour in *Sagittaria sagittifolia*,[11] *S. guayanensis*[11] and *S. latifolia*.[11] That the embryo sac of the Alismaceæ develops according to the Scilla-type and is as a rule only 6-nucleate, is also supported by the observations of Dahlgren (1928*, 1934[21]) on various other plants of the family. Johri[11] (1934) traced the development of the male and female gametophytes of *Cuscuta reflexa* Roxb. Peters'* (1908) statement on the absence of a middle layer in the anthers of *Cuscuta* is contradicted. The pollen grains were originally reported as 2-nucleate, but sections of older flowers recently cut for further study, reveal that the generative cell divides to form two male cells before the opening of the anther. The same author[11] has also studied the development of the gametophytes of *Berberis nepalensis* Spreng., and has called attention to the similarities between this family and the Ranunculaceæ. In another note, which is to be published shortly, he reports the presence of a 16-nucleate embryo sac in *Acalypha indica*, developing in essentially the same manner as was described by Miss Stephens* (1909) for the Peneaceæ, but several variations have been found with regard to the number of polar nuclei entering into the composition of the fusion nucleus.

Bhargava[13] (1932) published an account of the life-history of *Boerhaavia repanda*, which is essentially similar to *B. diffusa*, described earlier by Maheshwari.[16] The same author[11] has also studied the life-histories of *Mollugo nudicaulis* and *Trianthema monogyna*.† In both cases the development is normal, but in *Mollugo* the pollen grains were occasionally seen germinating *in situ*, and a third integument (hitherto unreported in the family) has been seen in the ovules of *Trianthema*. The same author has found that in *E. erecta*,[11] the tapetal cells form a periplasmodium and the pollen grains are 3-nucleate. The embryo sac develops normally, but there are sometimes only two antipodal cells, one of which is 2-nucleate. Later, the number of nuclei in the antipodal cells may increase, so that each is many-nucleate.

Puri[11] (1934) has reinvestigated the development of the embryo sac and embryo of *Moringa oleifera* and he finds that the previous observations of Rutgers,* recording the presence of a 5-nucleate embryo sac and free nuclear embryo in this plant, are unfounded. As a matter of fact, the embryo sac is of the usual 8-nucleate type and the first division of the egg is followed by wall formation as in other angiosperms. Occasionally the number of free nuclei in an embryo sac is more than eight, and some abnormal ovules with paired nucelli have also been seen. A feature of special interest is the presence of integumentary vascular bundles in the ovules.

Gupta[10] (1934) has described the development of the male and female gametophytes in *Potamogeton crispus*, and in another note, to be published shortly, he has reported some interesting variations in the life-history of *Wolffia arrhiza*.† Here the anther consists of only 2 loculi, parietal tissue is reduced to the endothecium and tapetum, and the pollen grains are 3-nucleate. The tapetal cells become amœboid and wander into the

anther loculus, while the epidermis disappears completely at maturity. The development of the embryo sac is of the Scilla-type and the antipodals and synergids are very ephemeral. The nucellus is absorbed at an early stage, except for a cap of cells which persists at the top.

Singh and Shivapuri[11] (1935) have studied the development of the gametophytes of *Neptunia oleracea* and Capoor[19] has done the same for *Ulmus integrifolia*. The latter has shown beyond any doubt that the embryo sac in *Ulmus* is of the normal type, arising from the chalazal megaspore of the tetrad. This necessitates a reinvestigation of *U. americana*, which is the only plant in the order Urticales, that has been reported to have a Lilium-type of embryo sac (Shattuck,* 1905).

Maheshwari[16] (1929) gave an account of the life-history of *Boerhaavia diffusa*. The pollen grains were originally reported to be 2-nucleate, but recently some 3-nucleate ones have also been seen. The ovule has a beak-shaped nucellus provided with a single integument, and the pollen tube travels down to the base of the funiculus and then turns into the tip of the nucellus. The number of antipodal cells increases to 6 or 7 after fertilisation (more recently, Bhargava has seen that in *B. repanda* this can happen even before fertilisation). The endosperm is free nuclear and the embryo is provided with a short but massive suspensor.

Maheshwari and Singh[6] (1930) found that in *Asphodelus tenuifolius* the embryo sac arises in the normal way, but a third integument begins to develop at an early stage, almost entirely enclosing the ovule after fertilisation. In a later communication, the first author reports that the endosperm is not free nuclear, but of the Helobiales-type. In another paper, the same author has described stages in the life-history of *Ophiopogon wallichianus*,[11] Hook. f., a member of the family Hæmoderaceæ. The life-history follows the normal course, but a primary wall cell may or may not be cut off in the ovules.

Maheshwari tried to find out the cause of the abortiveness of such a large number of flowers in *Albizzia lebbek*[20] and *Mangifera indica*[7] and found that in both cases it was due to widespread degenerations occurring at almost all stages in the anthers and ovules. The study of the life-history of the latter confirms the observations of Juliano and Cuevas[22] (1932), but the pollen grains are 3-nucleate at the time of shedding. The fertilised egg remains undivided for a long time—till about a thousand free nuclei have been formed in the endosperm.

Maheshwari and Gupta[7] (1934) have studied the development of the female gametophyte of *Ludwigia parviflora* and *Jussieua repens*. In both cases a linear tetrad of four megaspores is produced, but usually the micropylar functions. Sometimes the chalazal may also enlarge and occasionally some tetrads resembling an inverted "T" were seen in *Ludwigia*. The mature embryo sac is only 4-nucleate with an egg apparatus and a single polar nucleus. Sterility of the ovules was common and in *Ludwigia* several cases were encountered, where both nucellus and embryo sac had degenerated leaving only the integuments.

In a short note Maheshwari[4] has reported that in *Hydrilla verticillata* the anther-tapetum becomes amœboid, the pollen grains are 3-nucleate, the embryo sac is of the normal type, the endosperm of the Helobiales-type, and the embryo more or less resembling that of *Alisma*. Occasionally two paired nucelli were seen, each with its own inner integument, but enclosed within a common outer integument.

Maheshwari and Singh[7] (1934) have investigated the life-history of *Commelina benghalensis*, a common annual weed with white cleistogamous flowers developing underground and blue aerial flowers enclosed in a spathe. Of the three aerial flowers usually occurring in a spathe, one is male and two are hermaphrodite; of the latter, only one opens while the other is cleistogamous like the underground flowers. A true periplasmodium is present in the anthers and the presence of crystals of calcium oxalate in this is noteworthy. The nucellus forms a beak-shaped outgrowth, which comes up to the level of the micropyle. An important point is the presence of a normal tetrad of four megaspores, although it was previously considered that the development is of the Scilla-type (Guignard,* 1882, on *C. stricta*).

At Ajmer, Mathur[7] has been working, at the writer's suggestion, on the life-history of *Convolvulus arvensis*. The cutting off of a primary wall cell in the nucellus is a fact of interest, as there are very few cases in the Sympetalæ where the hypodermal archesporial cell does not directly function as the megaspore mother cell.

At Nagpur, Richaria[4] (1934) has been working on the development of the stamens in

several Asclepiads and it is reported that in spp. of *Hemidesmus*, *Cryptostegia* and *Cryptolepis* there are four sporangia in each stamen, while *Calotropis*, *Dæmia*, *Holostemma* and *Pergularia* have only two. In all cases except *Cryptostegia* and *Cryptolepis*, the microspores are arranged in the form of linear tetrads. In the last two genera, where the arrangement is tetrahedral, the pollinia are not well organised and form only a loose mass.

At Coimbatore, Dutt and Subba Rao[15] (1933) have investigated the development of the embryo sac and embryo of sugarcane. An abnormal case of an embryo sac with reversed polarity, pollen tubes with four male nuclei, and one case of polyembryony are recorded. In two cases it was seen that a few divisions had taken place in the egg, although the primary endosperm nucleus had not divided.

Investigations in Progress.

The above is a summary of what has been done, but several papers are in the press and many investigations are in progress.

At Benares, Tiwary is continuing his studies on the Myrtaceæ and has started additional work on the embryogeny of several Convolvulaceæ. Tiwary and Misra are studying the causes of sterility in *Hibiscus rosa-sinensis*, and Rao has almost completed his work on the embryo sacs of *Mærua* and *Antigonon*. Joshi and Venkateswarlu have completed their work on *Ammania baccifera*, and the first author is continuing further work on several plants of the Lythraceæ, Amaranthaceæ and Phytolaccaceæ.

At Calcutta, Banerji has completed his investigations on the embryology of *Arachis hypogea* and *Typhonium trilobatum*, and Samal has done the same for *Crotalaria juncea*. Das is working on *Trichosanthes dioica*; E. A. R. Banerjee on *Capsicum annuum*; Hedayetullah on some members of the Capparidaceæ; Datta on the Nymphæaceæ; Roy on *Aloe vera* and some Leguminosæ; and Bhaduri on several plants of the Solanaceæ.

At Agra, Capoor is working on the embryology of *Carica papaya*, *Urginea indica* and some members of the Urticales; Puri on *Anona squamosa* and *Moringa*; Bhargava on the Loranthaceæ and Capparidaceæ; Johri on the Euphorbiaceæ and Butomaceæ; Gupta on the Lemnaceæ; Singh on the Onagraceæ and Amaranthaceæ; and Maheshwari on *Hydrilla* and *Tamarix*.

At Nagpur, Nirula and Gadkari are working on the embryology of some Asclepiads; and at Ajmer, Mathur has started some work on the life-history of *Vogelia indica*. In the South, Ekambaram and Panje are working on *Balanophora*, Raghavan on *Cleome*, Seshagiriah on the Orchidaceæ, Chakravarthy on the Rutaceæ, and Laksminarasimha Murthy on some of the Commelinaceæ.

Future Outlook.

So far, the floral characters of angiosperms have been regarded as the most reliable taxonomic guides. While this may be true, it is no longer possible to ignore other factors. It is now being increasingly realised that an approach to a natural system of classification can be gained only by a study of the plants in their entirety. It is dangerous for specialists to go on classifying and rearranging plants merely on the basis of one set of characters with which they are most familiar. The crying need of the day is a classification, which also takes into consideration, embryology, wood anatomy, and the vascular supply to the floral organs. In future, any attempt, which does not take these factors into account, will be looked upon with half-heartedness.

A study of the existing literature reveals that among the families found in India, there is a great dearth of information with regard to the Menispermaceæ, Dilleniaceæ, Bixaceæ, Flacourtiaceæ, Sapindaceæ, Dipterocarpaceæ, Combretaceæ, Rhizophoraceæ, Sonneratiaceæ, Alangiaceæ, Punicaceæ, Bombacaceæ, Simarubaceæ, Sapotaceæ, Salvadoraceæ, and others; while the Piperaceæ, Santalaceæ, Loranthaceæ, Balanophoraceæ, Fumariaceæ, Resedaceæ, Podostomaceæ, Malpighiaceæ, Thymelaeaceæ, Elatineæ, Plumbaginaceæ and Pandanaceæ have yielded such exceptional results in the past, that further investigations on these would be welcome. Among special genera, which deserve a fresh study, the following may be mentioned particularly: *Lemna*, *Costus*, *Pandanus*, *Najas*, *Cypripedium*, *Typha*, *Casuarina*, *Salix*, *Opuntia*, *Codiæum*, *Euphorbia*, *Garcinia* and *Zizyphus*.

There also remain a number of our fruit trees and crop plants, which must be investigated both morphologically and cytologically before the principles of scientific plant breeding can be applied to them with confidence. It is true that most of these plants will not yield results of such academic importance as those suggested above, but they might lead on to discoveries from which

the country may reap a benefit running into large sums of money.

Some real difficulties have for a long time formed a bar to rapid progress in this work. One of these is the difficulty of obtaining properly fixed material. At present a person who wants to do such work, has to limit himself to such plants which grow in his neighbourhood, although actually he is often interested in investigating as many representatives as possible of a special family or order, with which he has gained most familiarity. A second and more serious difficulty is the paucity of literature in this country. Much time is spent in searching for the necessary references and some authors actually engage themselves in such work without knowing what has already been done on the particular family or genus in which they are interested. Those, who know the literature and maintain some sort of a card index to keep in touch with current papers, find it difficult to procure the original references for study. The only way to avoid this difficulty is to encourage the exchange of reprints and journals among responsible workers. It is a pity that those persons, who are themselves favourably placed with regard to this matter, are often very conservative in lending literature and do not realise the difficulties of others, who have to fall back to a great extent on their private resources for purchasing reprints and journals.

In spite of these difficulties a good beginning has been made. Fortunately there are several enthusiastic workers in the country, several problems awaiting investigation are lying at our very doors, and in some cases even funds are available. Given the necessary facilities and encouragement, and a true recognition of their labours, the future is bound to be bright. Individually these investigations may seem trivial, but they all swell the fountain of knowledge and it is this accumulated information, which will help future workers to solve questions on which we can at present only indulge in guess-work.

In the end, I wish to express my sincere thanks to all those who co-operated with me in supplying the necessary information, and particularly to my pupil, Mr. H. R. Bhargava, who helped me in the preparation of the bibliography.

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Chronica Botanica.

WE have pleasure to announce the publication of the first Volume of *Chronica Botanica*, a new international year-book, devoted to all branches of Plant Science, edited by Dr. Fr. Verdroon in collaboration with an Advisory Board and numerous Assistant and corresponding Editors. Plant Science has a new annual such as never before existed in any branch of Science. Prof. E. D. Merrill, Director, New York Botanical Garden, writes, "The *Chronica Botanica* as conceived covers a new field not hitherto pre-empted, conflicts with no established periodical, supplements those already in existence and should, by its very nature, encourage the spirit of international co-operation, a spirit characteristic of this, our science of which we as botanists representing all nations, are individually and collectively proud." This new publication will help all research workers interested in botany to keep in touch with the activities of the numerous Institutions, devoted to pure and applied botany. We have no doubt that the publication, so comprehensive and so useful, will be welcomed by everyone interested in Plant Science.

The Banded Ferruginous Quartzites of the Bababudan Hills, Mysore State.

By Charles S. Pichamuthu, B.Sc., F.G.S., F.R.S.E.,
Assistant Professor of Geology, University of Mysore.

ONE of the chief arguments for considering the banded ferruginous quartzites of the Bababudan Hills of Mysore, as being derived from the alteration of basic igneous rocks, has been founded on the occurrence of thin intercalated bands of schists, which have been variously described in the *Records of the Mysore Geological Department* as "hornblendic beds," "riebeckite and cummingtonite schists," "amphibolites," "hornblendic traps," and so on.

According to Dr. W. F. Smeeth,[1] "the hornblendic beds which are of the nature of amphibolites appear to alter gradually into quartz-iron ore rocks, and this is more noticeably the case where such amphibolites consist largely of the mineral cummingtonite" (1908, p. 21).

The late Prof. P. Sampat Iyengar[2] considered the magnetite quartzites as derived from the alteration of riebeckite and cummingtonite schists. The thin quartz layers of the rock appeared to him to be "partly secondary enrichment in the schists at the expense of the cummingtonite, and partly the result of intrusion in the schists, of several thin quartz veins" (1908, p. 73). He explained the fine banding of the quartzites as the consequence of *lit-par-lit* injections of quartz veins in the amphibolites, the regularity of the banding being augmented by subsequent pressure which acted upon the whole mass of the schists (1908, p. 76).

H. K. Slater[3] was of the opinion that the banded magnetite hematite quartzites were produced "through the metamorphism and oxidation of the bands of amphibole, which vary from one inch to three feet in thickness, that form the aphanitic greenstones" (1908, p. 56).

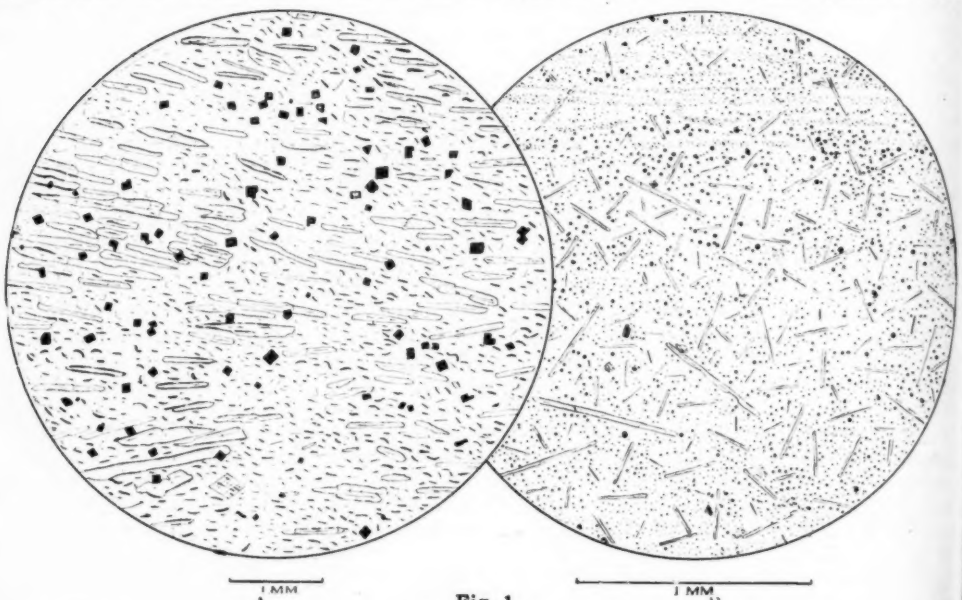


Fig. 1.

A. Micrograph of bababudanite-magnetite schist.
B. Micrograph of hornfels with decussate structure. The section shows the banded nature of the rock.

[1] Smeeth, W. F., "General Report of the work of the Department for the year 1907–8," *Rec. Mys. Geol. Dept.*, 1908, **9**.

[2] Sampat Iyengar, P., "Geology of parts of Hassan and Kadur Districts, Mysore Province," *Rec. Mys. Geol. Dept.*, 1908, **9**.

[3] Slater, H. K., "Report on the Geological Survey of a portion of the Kadur District," *Rec. Mys. Geol. Dept.*, 1908, **9**.

B. Jayaram[4] thought that the iron ore formation had little to do with the "alteration, silicification and ferruginitisation of the older hornblendic or later hornblendic traps that are underlying the above formation" (1923, p. 40). He did not, however, offer any suggestions as to the probable mode of origin of these rocks.

I have recently examined these intercalated schists both in the field and in the laboratory, and find myself unable to agree with the views advanced by Smeeth and Sampat Iyengar. These schists are often only a few inches in thickness, and are impersistent. Examples of bababudanite schists can be seen on the road sections between the 28th and 29th miles on the Chikmagalur-Lingadhalli road. They are crowded with glistening crystals of the amphibole. The microsections (*vide* Fig. 1A) show a felted or banded aggregate of acicular crystals of bababudanite which exhibit a very beautiful pleochroism from yellow to violet to blue. The matrix is formed of granoblastic quartz. So abundant are the crystals of magnetite scattered through the rock, that it is preferable to designate it as bababudanite-magnetite schist. The above description would make it clear that these schists bear no resemblance either texturally or mineralogically to the epidiorites which occur as dykes and lava flows in the area.

In order to elucidate more definitely the nature of this rock, a chemical analysis was made of a specimen of the bababudanite-magnetite schist occurring near Kemmangundi. The results are given under column I in the above table. A–D are analyses of amphibole magnetite rocks occurring as intercalations in the Lake Superior banded ironstones of Michigan and Wisconsin, and which are considered to be of sedimentary origin. It will be seen that the Mysore rock compares very well with these analyses. P and Q are partial analyses of somewhat similar amphibole bearing rocks from the Singhbum District, India. In these two analyses, only the percentage of metallic iron has been determined, and so, to facilitate comparison, the percentages of metallic iron in the other analyses have been calculated.

	I	A	B	C	D	P	Q
Fe	34·3	37·8	36·6	41·1	34·5	35·2	36·4
SiO_2	44·15	39·17	42·90	33·89	46·25	38·80	37·28
Al_2O_3	0·25	1·14	..	1·15	0·92	0·20	0·40
Fe_2O_3	40·20	40·42	34·77	49·43	30·62		
FeO	7·98	12·33	15·82	8·46	16·92		
MgO	3·11	1·90	2·62	2·40	2·13	4·32	2·46
CaO	tr	1·37	1·33	3·16	1·69	2·55	2·35
Na_2O	2·60	..	..	..	..	..	
K_2O	tr	..	..	..	..	..	
H_2O^+	0·05	2·56	0·47	1·50	0·42		
H_2O^-	1·60						
TiO_2	tr	..	..	..	..		
P_2O_5	tr	tr	tr	..	0·07		0·05
MnO	..	0·55	1·73	0·34	1·01		
CO_2	..	..	..	..	..		
	99·94	99·44	99·64	100·33	100·03		

I. Bababudanite-magnetite schist, Bababudan Hills, Mysore. Analyst: W. H. Herdsman, Glasgow.

A, B and C. Magnetitic slates, Wisconsin (Irving & Van Hise,[5] 1892, p. 197).

D. Grünerite-magnetite schist, Michigan. Analyst: H. M Stokes. (Van Hise, Bayley & Smyth,[6] 1897, p. 338).

P. Iron ore-amphibole rock, Badampahar Iron Mines, Noamundi, Singhbum District, India. (Percival,[7] 1931, p. 199).

Q. Actinolite bearing recrystallised banded hematite silica rock, Badampahar. (Percival, 1931, p. 224).

It will be seen from the above analyses that the Mysore rock contains 3·11% of MgO as against a trace of CaO. The dominance of magnesia over lime is suggestive of a sedimentary origin. Van Hise and Leith[8] considered that the Lake Superior iron bearing formations must have been chemically precipitated because the average proportion of magnesia to lime is over 5 to 1 (1911, p. 506). A similar calcium-magnesium ratio has been observed in the Noamundi area by Dr. Percival (1931, p. 200), who is of opinion that these banded iron ores have originated as chemical sediments. The dominance of ferric over ferrous iron noticed in the bababudanite-magnetite schist, when considered in conjunction with the magnesia-lime ratio, strengthens the view that these rocks must have had a sedimentary origin.

A striking difference which the analysis

[4] Jayaram, B., "Progress Report on work done during the field season of 1919–20," *Rec. Mys. Geol. Dept.*, 1923, **20**.

[5] Irving, R. D., and Van Hise, C. R., "The Penokee Iron-bearing Series of Michigan and Wisconsin," *Mon. U.S. Geol. Surv.*, 1892, **19**.

[6] Van Hise, C. R., Bayley, W. S., and Smyth, H. L., "The Marquette Iron-bearing District of Michigan," *Mon. U.S. Geol. Surv.*, 1897, **28**.

[7] Percival, F. G., "The Iron Ores of Noamundi," *Trans. Min. Geol. Inst. India*, 1931, **26**.

[8] Van Hise, C. R., and Leith, C. K., "The Geology of the Lake Superior Region," *Mon. U.S. Geol. Surv.*, 1911, **52**.

of the Mysore schist exhibits, is in the presence of 2·60% of Na_2O. The igneous rocks adjoining and underlying the banded ferruginous quartzites of the Bababudan Hills, are many of them rich in soda, as may be seen from the prevalence of albite and acid oligoclase. I ascribe the soda content of the bababudanite-magnetite schist to the sediments being derived from these spilitic rocks.

Jayaram looked upon bababudanite as a "secondary metamorphic mineral derived from the alteration of impure grits and tuffs of the Champion gneiss series" (1923, p. 40). This is followed on the next page, by the statement, "the occurrence of this amphibole seems to be precisely comparable to that of tourmaline in the altered acidic rocks of the Champion gneiss series," which makes it rather difficult to understand his view regarding the origin of this amphibole.

In a previous note in this journal[9] (Pichamuthu, C. S., and Srinivasa Rao, M. R., 1933, pp. 276–77), it was shown that the amphiboles occurring in the banded magnetite quartzites of the Bababudan Hills were formed by contact metamorphic action due to the intrusive epidiorite dykes, and had nothing to do with the origin of the ironstones themselves. I consider the bababudanite-magnetite schists also to have had a similar origin.

In view of the suggestion made by Slater, that the banded ferruginous quartzites have been produced through the metamorphism of layers of a rock described by him as "aphanitic greenstone," I carefully examined the occurrences of this rock, not only from his type area near the 23rd milestone on the Chikmagalur-Lingadhalli road, but from several other exposures in the road sections between Mulaingiri (△ 6310) and Kondekhan (13° 33′ : 75° 46′). These are usually very thin intercalations, often exhibiting extraordinarily fine bandings. The rock is dark in colour and mixed with abundant ferruginous dust. When altered, it is converted into a yellow ochreous material. There is practically no grit. The exposures of this rock near the Kondekhan coffee estate house are highly jointed, the joint faces being very smooth. The specific gravity of specimens collected here is 2·65; in other parts of the Bababudan Hills, I have observed a range in specific gravity between 2·51 and 2·75. Sections cut from this rock do not exhibit any igneous character. The rock could best be described as a mudstone or argillite.

The rock is normally soft but has been hornfelsed near igneous contacts, with the result that it has become extremely compact and tough, the fracture suggesting a glassy rock. This is caused by the development of mica or amphibole with the typical decussate structure characteristic of a hornfels (*vide* Fig. 1B).

From what has been said above, it will be seen that the amphibole-magnetite schists of the Bababudan Hills have developed in certain bands as the result of contact metamorphism, and that they do not represent remnants of the parent rock from which the banded ferruginous quartzites have originated. The "aphanitic greenstones" of Slater are merely interbanded argillitic layers which have become hornfelsed near igneous intrusives.

[9] Pichamuthu, C. S., and Srinivasa Rao, M. R., "Amphiboles in the Bababudan Iron Ore Rocks," *Current Science*, 1933, 1.

Madras Fisheries Department.

RECORD of another year's good work is contained in the Administration Report of the Madras Fisheries Department for the year 1933–34.

"The outstanding event of the year which has brought back some measure of prosperity to the fishing industry of the West Coast was the return of the oil sardine in unexpected abundance after an absence almost complete for an unusually long series of years." It is unfortunate, however, that maximum advantage could not be taken of the abundance of fish owing to the prevailing economic depression. Attention may here be directed to an observation made by the Director (p. 22): "When the sardines became rich in oil, and boat loads were available at a nominal price, the station had run out of funds. When the funds were actually sanctioned, the sardines had ceased to occur and the amount had to lapse." It shows that the Government methods in dealing with economic problems require revision and it seems desirable that there should be a special provision in the departmental budget which could be drawn upon only in cases of emergency.

The oil sardine is unquestionably the

most important economic fish of the West Coast and any efforts made to study its migratory habits and to forecast its relative abundance year by year will no doubt help to ameliorate the condition of the fishing industry permanently. In Western countries years of observations and experiments have yielded valuable data regarding the wanderings of the principal food-fishes and it is gratifying to learn that similar observations were made during the year by the Madras Fisheries Department with regard to oil sardines to elucidate the causes responsible for the abundance of the species during 1933. At present the data collected may not give any clue to the solution of the problem, but series of such observations carried over a number of years are bound to prove useful. The feeding and breeding habits of the oil sardine and the hydrographical data of the areas of their occurrence are likely to yield interesting results. The abundance of the species along the Malabar Coast shows that it prefers waters of fairly high salinity and their time of occurrence is such—August to December, period of maximum abundance in 1933 being last week of October—that there is usually a considerable change in the coastal fauna of India due to the lowering of the salinity in certain areas on account of the monsoon rains.

Hilsa is another migratory fish of great economic importance and the Madras Fisheries Department has been carrying out investigations regarding its artificial culture and life-history. Regular observations in the field have revealed that in the Godavari below the Dowlaishweram *Hilsa* of varying sizes are present throughout the year. The Director observes that "At any rate the important fact that young *Hilsa* up to 8¼ inches reside in the lower reaches of the river and do not go to the sea seems fairly well established." The publication of the full results of these investigations will be watched with considerable interest by Bengal and Sind where there is an extensive fishery of this species.

The migratory habits of *Hilsa* seem to be associated with the lowering of the salinity of the sea water on account of heavy rains. The abundance of the species along the East Coast and its absence along the West Coast also point to the same conclusion. The Department's efforts to introduce *Hilsa* along the West Coast are not likely to meet with success as there are no large rivers in that area for the fish to run up for spawning purposes.

Catla, a tank-fish of northern India, has been successfully introduced in the Madras Presidency where it flourishes in reservoirs, tanks, and in the lower reaches of the Cauvery. It is doubtful, however, whether any good can result from the stocking of the upper waters of the Cauvery because the fish is not adapted to live in clear, rapid-running waters. In all such experiments it is most essential that due regard should be paid to the ecology of the species subjected to artificial cultivation.

The report shows advance in our knowledge in several other respects also, as for example, the success obtained in keeping live oysters under artificial conditions at the Krusadi Biological Station, the construction of effective barriers against the enemies of pond-fishes, the success obtained in the use of CO_2 as the best preserving medium for the long storage of prawns, etc., etc. The achievements of the Department have encouraged the Imperial Council of Agricultural Research to subsidise a scheme of research for a central freshwater biological station and fish farm at Madras and another scheme of research relating to fish oil, guano and manure.

It is recorded with great satisfaction that a course of lessons in pisciculture is in preparation by the Department. It was a long-felt need and the fisheries are bound to benefit by such a regular course of training of the young men of the fishing community.

The report besides containing matters of general administration, is full of scientific results obtained by the Department during 1933–34. The Department, especially its energetic Director, is to be congratulated on the success achieved and it is hoped that under the patronage of the Imperial Council of Agricultural Research it will be possible to usher in a new era of fishery research in India.

S. L. H.

Letters to the Editor.

On the Dissociation of Some Molecules with Free Valencies.

IN continuation of an earlier paper[1] the correlation between the electronic terms of molecules of the type BeO, BeF and NO and those of the constituent atoms has been examined with the following conclusions :—

(i) Among the oxides and halides of the metals of the second group a good agreement between the energy of excitation of the products of dissociation and the terms of the metal atom obtains always, if the ground level of the molecule is correlated to the excited term sp ^3P of the metal. Besides the molecules BeF, MgF, CaF, SrF, already examined before, the following have been considered: BeO, MgO, CdF, BeCl, MgCl, CaCl.

(ii) In some of the molecules of these types also a correlation of the ground level to the repulsive term $s^2\ ^1S$ would appear to be possible, but others strictly contradict such a correlation. This is particularly evident in a case like CdF. Here the term difference $5s\ 5p\ ^3P - 5\ s^2\ ^1S$ is enlarged, the metal belonging to the sub-group of the periodic table, while the energies of excitation and dissociation of the molecule are not very different from others of this type. Consequently one would have to assume that the linear extrapolation of the vibrational levels is incorrect by about 85 per cent. in order to obtain a correlation of the lowest state of the molecule to the ^1S term of Cd. The correlation to the excited term always agrees to about 1 to 2 per cent. with the experimental data.

This not only establishes the repulsive character of the s^2 group, but also, since no perturbation is observed in the bands, the absence of that type of hybridisation, which involves more than one term of the metal atom (q-linkage). This is also borne out by the crystal structure of the oxides which cannot be explained unless the single molecule exhibits still free valencies.[2]

(iii) In all the above molecules, terms whose energy of excitation is larger than that of the ground level are automatically correlated to an *anomalous* term of the metal atom.

(iv) In the molecules NO, PO and AsO the term with an increased energy of dissociation involves a configuration of the corresponding atom of the fifth group in which one electron is already excited to the next shell. A reasonable correlation can be obtained in SbO on the assumption that it behaves similarly. Of the different electronic terms whose relation is not yet known experimentally, the final state of the D system is to be regarded as the ground level of the molecule and the common final state of the B and C systems as the term with increased energy of dissociation.

This shows again that the increase of stability on excitation in these molecules is always due to the excitation of that electron which does not take part in the linkage but represents a free valency.

A detailed report will be given elsewhere.

H. LESSHEIM.
R. SAMUEL.

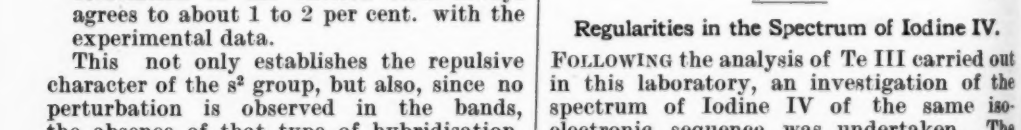
Muslim University,
Aligarh,
May 15, 1935.

[1] H. Lessheim and R. Samuel, *Zs. f. Phys.*, 1933, **84**, 637; **88**, 276.

[2] F. Hund, *Zs. f. Phys.*, 1932, **74**, 1.

Regularities in the Spectrum of Iodine IV.

FOLLOWING the analysis of Te III carried out in this laboratory, an investigation of the spectrum of Iodine IV of the same iso-electronic sequence was undertaken. The spectrum of a condensed discharge through Iodine vapour was photographed at various stages of excitation, by using a Quartz Spectrograph of the Littrow type. The data thus obtained has led to the discovery of the important interval $6s\ ^3P_1 - {}^3P_2 =$



H.—Higher Excitation. L.—Lower Excitation.

Quartz Spectrogram of Iodine Discharge.

8252·3 cm.$^{-1}$, along with all the terms of the 6p-configuration. Adopting for the level $6s\,^3P_1$, a value 200532 cm.$^{-1}$ extrapolated from the corresponding values in Sn I, Sb II and Te III, a number of odd levels of the values of 202767, 201270, 200339, 199981, 198423, etc., have been obtained. Some of the important lines in the spectrum are marked in the print above. The detailed scheme will be published shortly.

S. G. KRISHNA MURTY.

Andhra University,
Waltair,
June 2, 1935.

Diamagnetism of Elements in the Powdered State.

IT has been reported, that powders of bismuth,[1] antimony,[2] gold,[3] silver,[4] selenium,[5] etc., have considerably different susceptibility values than the metals *en masse*. In 1930 Bhatnagar[6] drew attention to the fact that the large changes reported in susceptibility could be due to a considerable extent to the presence of oxides and suboxides of the metals and to the adsorption of impurities by the fine powders. Mathur and Verma following this suggestion showed that after the removal of oxides both bismuth[7] and antimony[8] powders regain the original regulus value.

Rao[9] from his work on bismuth and antimony maintains that he obtains a critical value corresponding to the size of the macrocrystal after which a rapid change in the susceptibility ensues.

From Rao's papers one does not feel convinced that a high order of purity of materials has been attained in his experimental work. In the case of antimony, for example, no effort has been made to free it from the oxides. In the case of bismuth also, while an attempt has been made to free it from the oxides by treatment with tartaric acid as suggested by Bhatnagar, no critical experimental evidence has been given to show that the oxide is really completely removed. Nor has the probability of contamination with carbonates or bicarbonates been excluded, since it is well known[10] that these products are formed by keeping bismuth under water in the presence of air.

Selenium was examined by Dharmatti, who showed that on powdering, the diamagnetic susceptibility decreased and eventually changed in sign becoming paramagnetic. We have repeated Dharmatti's work and have some interesting observations to record. The red and grey allotropic varieties of selenium were subjected to prolonged powdering under benzene or toluene to prevent oxidation as far as possible. Only in an extreme case the value decreased from $-3\cdot03\times10^{-7}$ to $-2\cdot69\times10^{-7}$ at a particle size of $0\cdot4\,\mu$. In each case, however, the sample recovered the original value after washing with cold dilute hydrochloric acid. Also one of Dharmatti's paramagnetic samples made available to us through the courtesy of Prof. Mata Prasad regained the original value of Se on treatment with hydrochloric acid.

A very interesting observation made by us during the investigation was that the red variety gradually passed into the black one on protracted exposure to light. Transformation into the black variety has also been shown to take place under pressure by Von Schrott[11] and we suggest that the fall observed in certain cases may be due to the conversion on powdering into a metastable allotropic form having its susceptibility different from the original substance. This possibility seems particularly likely in the case of tin, which has been examined by Rao.[12] White tin *en masse* is weakly paramagnetic, but Rao finds that in the powdered form the susceptibility decreases with the particle size until for the smaller particles he finds that it becomes diamagnetic. As in previous cases, Rao has not taken care to discover the possibility of anything else responsible for the change. We are examining the case of tin and hope to communicate our results later.

In the end the authors wish to emphasise once again that in any work done with particles of colloidal sizes the exclusion of impurities which do accompany the powders on colloidisation is of permanent importance for it is only this, that can be responsible for erroneous conclusions. The authors also take this opportunity of thanking Prof. S. S. Bhatnagar for his help and guidance at every stage.

MULK RAJ VERMA.
I. C. GUPTA.

University Chemical Laboratories,
University of the Punjab,
Lahore.
June 4, 1935.

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The Diurnal Variation of Moisture in the Soil during the Clear Season.

EXPERIMENTS on soil moisture conducted by the Agricultural Meteorology Branch at Poona during the last two clear seasons (October-April) have shown[1] that during the clear season at Poona, when the surface layer of the soil is so far desiccated as to contain only hygroscopic moisture, the evaporation from the soil during the day is followed by absorption of moisture from the atmosphere during night by the soil. Under these conditions the soil does not undergo any material loss of moisture from day to day. The evaporation from and absorption by the soil result also in a variation of moisture in the air layers near the ground. These phenomena are therefore of particular interest to those engaged in a study of micro-climates and the meteorology of the air layers near the ground. This aspect of the subject has also been discussed in the above-mentioned paper.

In a later communication[2] we reported that samples of different soils kept in small vessels show characteristic intensities of "evaporation" and "absorption" when exposed to identical meteorological conditions. These observations have been confirmed by further experiments with a variety of soils during the last clear season.

The amplitude of the diurnal variation in the moisture contents of different soils expressed as a ratio of that of the Poona soil are given below :—

Name of Soil	Diurnal variation of moisture content expressed in terms of Poona Soil (=1).
Poona black cotton soil ..	1·00
Dharwar black cotton soil ..	1·10
Sholapur black soil ..	1·04
Hagari ..	0·86
Red Laterite ..	0·81
Ranchi ..	0·65
Jhelum ..	0·44
Bangalore ..	0·29
Pusa (alluvial) ..	0·20
Lyallpur (alluvial) ..	0·21
Sakrand (alluvial) ..	0·19
Quartz powder ..	0·00

The above table shows that the black cotton soils undergo the maximum diurnal variation of moisture content owing to the loss of water by evaporation during day and gain by absorption from the air during night. The alluvial soils from the Indo-Gangetic as well as the Sindh areas experience only a fifth of the diurnal variation shown by the black cotton soils. Quartz powder appears at the bottom of the list with no variation. It is indeed remarkable that soils of the same type from places as far from each other as Pusa, Lyallpur and Sakrand have the same moisture variation index. A similar remark applies to the black cotton soils as well.

The epoch of *minimum soil moisture* content occurs a few hours after the epoch of maximum soil surface temperature (which occurs at noon), and coincides with the epoch of "maximum air temperature and minimum percentage humidity". The epoch of *maximum soil moisture* content coincides with the epoch of "minimum air temperature and maximum percentage humidity".

The hourly variation of the moisture content of the Poona soil at different depths has also been studied by taking actual hourly samples from the field and determining their moisture contents. It is seen that the diurnal variation is maximum at the surface and decreases very rapidly with depth, being practically insignificant even at a depth of 1″ below the surface.

The mechanical and chemical analysis of the soils used by us, the study of their adsorptive properties under laboratory conditions as well as experiments on their heats of adsorption and wetting are in progress.

The results briefly outlined here are being discussed more fully in a forthcoming paper.

L. A. RAMDAS.
M. S. KATTI.

Indian Meteorological Department,
Poona.
June 12, 1935.

[1] "Agricultural Meteorology: Preliminary studies on soil moisture in relation to moisture in the surface layers of the atmosphere during the clear season at Poona", by L. A. Ramdas and M. S. Katti, *The Indian*

Journal of Agricultural Science, Vol. 4, part 6, pp. 923-937.

2 "The Variation of Moisture in the surface layer of the soil in relation to the diurnal variation of Meteorological Factors," by L. A. Ramdas and M. S. Katti, *Current Science*, July 1934, Vol 3, No. 1, pp. 24-25.

A Note on the Genus *Mitteriella*.

THE genus *Mitteriella* has been described by Sydow and Mitter[1] as a parasite on the leaves of *Zizyphus rotundifolia*. The specimen was collected from Majhgawan (a hilly tract between Manikpur and Satna, on the G. I. P. Railway). In 1930 when the material was first collected, very few bushes showed any sign of the parasite and only a single bush was badly infected. Here too, only the leaves were infected and branches or fruits were free from the fungus. Subsequent visits to Majhgawan year after year clearly revealed that the disease was becoming more and more common, because it was found that the leaves of a much larger number of *Z. rotundifolia* plants suffered from the same fungal infection. The luxuriant growth of the fungus observed in the first year was not found from 1932 to 1934 and no part of the plant except the leaves showed any sign of the parasite. During my last visit in January 1935 it was observed that the fungus was growing vigorously on many bushes and in addition to the leaves numerous branches and fruits were also infected by it.

All the figures were drawn with the aid of a camera-lucida. Magnification—about × 650.

1—Branched hyphæ showing "Pseudopodia" (P).
2—A single attached spore.
3—2 attached spores arising near each other.
4, 5, 6, 7—Spores of various shapes showing different number of septa—Hyaline areas (H) are present in every spore.

From 1930 to 1934 a careful search was made for it in the neighbouring localities but was not found on this (*Z. rotundifolia*) or any other host. In 1935, however, during a

visit to Chitrakot it was found that numerous bushes of *Zizyphus œnoplia* were badly infected by *Mitteriella*. Every aerial part of the tree including the fruit showed serious infection.

This fungus has also been found on the fruit of *Zizyphus jujuba* collected from Majhgawan. The fungus growing on *Z. jujuba* and *Z. œnoplia* agrees with *Mitteriella zizyphina* in all details and therefore it is concluded that the three host species of *Zizyphus* mentioned above are infected by a single known species of the fungus, namely, *Mitteriella zizyphina*.

The following observations based on an examination of numerous collections seem to be worthy of record :—(1) The infection is greater during or after a severe spell of cold, and (2) The shady side of the bush is least and the sunny side most heavily infected.

R. N. TANDON.

Department of Botany,
The University,
Allahabad.
March 27, 1935.

[1] Sydow, H., and Mitter, J. H., "Fungi indici—1," *Annales Mycologici*, 1933, **31**.

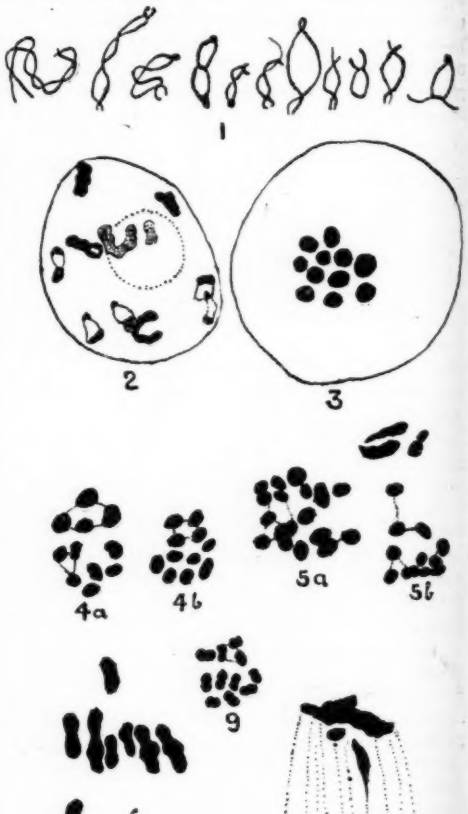
Chromosome Numbers in *Cajanus indicus*, Spreng.

IN the course of the examination of some pulses it was noticed that the chromosome numbers of some of them were not determined. One of them was the Dholl, *Cajanus indicus*, Spreng.— the pigeon pea, an important Indian pulse. The examination of this pulse was begun and the necessary material collected from the crop at the Millets Breeding Station in 1933.

Flower buds from the three following varieties were collected : (1) Short and early, (2) Medium height and duration, and (3) Tall and very late. (1) and (2) differ in degree ; (3) is a type with markedly big pods and seeds.

Flower buds were killed between 9 and 11 a.m. in Carnoy's fluid, which proved a good fixative on account of the hard calyx cup. Good fixations were also obtained in Allan's modification of Bouin's fluid when the buds were trimmed off at the top and bottom before being killed. The calyx on account of the hairs and oily exudations it contains, becomes hard and does not cut well. Its removal facilitates penetration. Sections were cut at 7–10μ and stained in Iron-alum Hæmatoxylin. Picric acid was used for destaining. All drawings were made with a Zeiss Camera Lucida, K. ×15 ocular and 1·3 H. I. ×90 objective. Figures were drawn to a magnification of approximately × 3000.

The first division stages are seen in buds 1–2 mm. long between 9·30–10 a.m. Later fixations give mostly second divisions. The



spireme is rather thin. At diplotene three chromosomes are seen to be longer than the others. The longer ones show more than 4

chiasmata, three out of the rest show 3 chiasmata and the remaining 5 show 2 chiasmata (Fig. 1). At diakinesis the latter show the chiasmata terminalised. Eleven pairs were counted at diakinesis (Fig. 2). The metaphase plate also gave 11 pairs (Fig. 3). In each variety 25 pollen mother-cells were counted and all of them gave the same number. This number eleven is the basic number of the *Phasioleæ* of which *Cajanus* is one.

The metaphase plate in all cases showed the chromosomes to be in association of 2, 3, 4 and rarely 5 (Figs. 4 *a* and *b*). No clear indications of such associations could be seen at diakinesis. Out of the 40 pollen mother-cells counted 25 were grouped up as follows:— 1+1+2+3+4. In other cases, associations in other groupings were also met with. The early anaphase gave also some indications of this association (Figs. 5 *a* and *b*).

Generally the anaphase is regular. In a few pollen mother-cells, however, one pair was found to be much earlier than the others and in other cases one pair was much later (Figs. 6 and 7). In the latter case the daughter chromosomes were seen slightly extended along the spindle. All the chromosomes reach the poles. The daughter nuclei gave eleven chromosomes (Fig. 8). One or more additional nucleoli were found in the resting daughter nucleus. No cell wall was formed.

Division II is generally more or less at right angles to the plane of Division I. The metaphase plates show the same associations here also (Fig. 9). The segregation is regular. A number of secondary nucleoli are seen. These are prominent in the early stages of the daughter nuclei formation but later become less evident.

The tapetum consists of one or two layers of large cells which often protrude into the anther cavity. These are seen persistent to a very late stage. The tetrads are formed by fission. The pollen is large, roughly triangular. The extine is thick and warty.

Since the above details were recorded, Basudev Roy[1] in the course of his "Studies in the Development of the Female Gametophyte in Some Leguminous Crop Plants of India," merely records 11 as the haploid number in *Cajanus indicus*. In view of the above detailed working of the cytology of this plant, this note is published.

N. KRISHNASWAMI.
G. N. RANGASWAMI AYYANGAR.
Agricultural Research Institute,
Coimbatore,
April 15, 1935.

[1] *Ind. Jour. Agri. Sci.*, 1933, 3, Part VI, p. 1098.

Variation of Chromosome Numbers in Musaceæ.

WHITE[6] believed that the basic chromosome number in *Musa* was 4; Cheesman[1] showed that the basic number in the "banana series" is 11, and that all the edible bananas should be looked upon as triploids. He further suggested that this basic number is a secondary number probably derived from an original haploid number 8. This view is further strengthened by the fact that Tischler[5] found 8 "units" during the reduction division in the P.M.C. of a variety of banana described as "Dole" from Amani. The diploid number for this species, however, has been determined later on by Cheesman and Larter[2] to be $2n=22$. Similar observations have been made by us in a species provisionally identified as *Musa rubra* Wall., the details of which will be published later. In a recent publication, however, Cheesman and Larter[2] have found that the basic chromosome number in the three sub-genera of Musa (Physocaulis, Eu-musa, and Rhodochlamys), is different being 9, 11 and 10 respectively. From a comparative study of chromosomes in the different species of Musa and other genera they have arrived at the conclusion that the ancestral basic number of chromosomes in Musa is less than 11 and there exists a "heterogeneity rather than affinities, not only in the family Musaceæ but within the genus Musa itself".

Chromosome counts of the following species and varieties of Musa and Heliconia have been made in this laboratory and interesting results obtained showing a variation in the diploid number which are presented below.

It will be seen from the table that all the edible bananas studied have 33 as their diploid chromosome number. The only seeded variety studied, in the Eu-musa section, namely, *var. Aithya* has on the contrary $2n=22$ chromosomes. These observations corroborate the view of Cheesman and Larter[2] that the basic number in the Eu-musa section is 11. The present count of $2n=33$ in the variety *Amritasagar*, however, is not in agreement with White's[6] observations who finds $2n=36$ for the same variety.

TABLE I.

Name of the Species and Varieties		Diploid Chromosome Number
Genus :—Musa		
Sub-Genus :—Eu-musa		
Musa paradisiaca L.		
Sub-species : *sapientum*.		
Vars.	Champa kela	32, *33*, 34 & 35
	Safri	32, *33* & 34
	Kancha kela	33
	Aithya	22
	Kabri	33
	Dudsagar	33
	Amritsagar	33
	Agniswar	32, *33*
	Penang	33
Musa Cavendishii Lamb.		
	Kabuli kela	33
—Rhodochlamys		
Musa rubra Wall.		*22* & 23
—Physocaulis		
Musa superba Roxb.		18
Genus : —Heliconia.		
Heliconia metallica Planch.		16, 18, *20* & 22

The other species provisionally identified as *Musa rubra* Wall. showed $2n=22$ chromosomes, though a clear plate showing 23 chromosomes has been observed. This observation appears to go against the view that the basic chromosome number in the section Rhodochlamys is 10.

In *Musa superba*, one of the two species representing the Physocaulis section of Musa in India, the diploid number was found to be $2n=18$, which is in agreement with the view of Cheesman and Larter,[2] that the basic number in this section is 9.

In *Heliconia metallica* Planch. a constant variation in the diploid chromosome number has been observed. Out of 25 clear plates, 3 showed 16, 4 showed 18, 10 showed 20 and 8 showed 22 as their diploid number. Cheesman and Larter on the other hand found the diploid number to be $2n=24$ in five out of six species investigated by them, and only in *Heliconia seemannii* they found the number to be $2n=22$. It is interesting to note, however, that according to Schumann[4] *Heliconia seemannii* Van Houtte ($2n=22$), one of the species investigated by Cheesman and Larter,[2] is synonymous with *Heliconia bihai* L. ($2n=24$). It appears, therefore, that variation in the diploid number of chromosomes in the same species is common in the genus Heliconia.

An aneuploid variation in the diploid number of chromosomes in the same plant has been previously recorded by d'Angremond[3] and Cheesman[1] in certain progenies of Musa hybrids. Cheesman and Larter[2] have found such a variation in the different roots of the same plant, the "Jamaica seedlings". According to them, these variations, though frequent, are due to chromosome fusion or loss during mitosis. From the above list, however, it will be seen that a constant variation in the diploid number of chromosomes, in the different cells of the same tissue, is a common phenomenon to be met with in certain varieties of Musa and Heliconia.

The presence of bi-nucleate and poly-nucleate cells and double number of chromosomes have been described by Cheesman and Larter[2] to be common in some varieties of Musa. Bi-nucleate cells have also been observed during the present study both in Musa and Heliconia, though double number

of chromosomes have not been observed up till now.

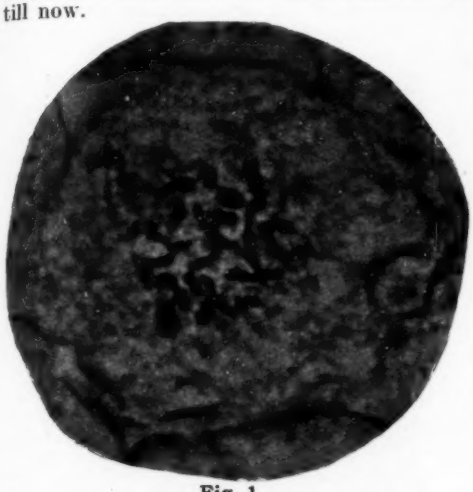


Fig. 1.
Musa paradisiaca L. Sub-Sp. *sapientum*. var. Champa Kela, stained with Haidenhain's Iron-alum Hæmatoxylin. ($2n=33$) ×2300.

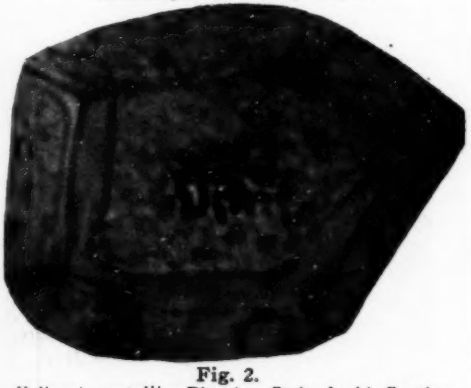


Fig. 2.
Heliconia metallica Planch. Stained with Gentian Violet. ($2n=16$) ×2600.

It will be seen from the measurements given below as also from the figures above,

TABLE II.

Name of the species and varieties	Length of Longest Chromosomes μ	Length of Shortest Chromosomes μ
Musa paradisiaca L. Sub. sp. *sapientum*		
Var. *Safri*	2·0	1·5
Aithya	2·5	1·5
Musa rubra Wall. ..	2·7	1·7
Musa superba Roxb. ..	2·7	1·7
Heliconia metallica Planch. ..	2·0	1·1

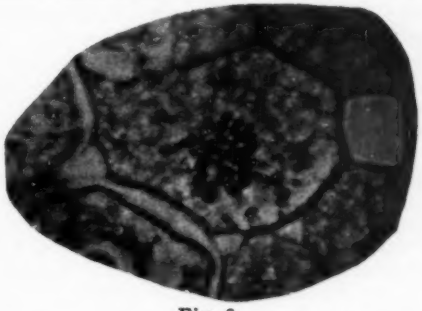


Fig. 3.
Heliconia metallica Planch. Stained with Haidenhain's Iron-alum Hæmatoxylin. ($2n=20$) ×1800.

that a variation in the sizes of chromosomes is marked in both Musa and Heliconia.

The marked tendency to grouping of chromosomes in chains, as has been observed during the present study, in some of the edible bananas and its absence in the seeded species, *Musa superba*, is another significant feature which has not been recorded by previous authors.

A more detailed investigation is in progress.

S. P. AGHARKAR.
P. N. BHADURI.

Department of Botany,
Calcutta University,
April 26, 1935.

[1] Cheesman, E. E., *Jour. Genet.*, 1932, **26**, 291–312.
[2] Cheesman, E. E., and Larter, L. N. H., *Jour. Genet.*, 1935, **30**, 31–52.
[3] d'Angremond, A., *Handel. Vierde Nederlandsch-Indisch Natuur. Congr., Velteverden.*, 1926, 360–367.
[4] Schumann, K., *Das Pflanzenreich.*, Leipzig, 1900, **4**, 45.
[5] Tischler, G., *Arch. f. Zellforsch.*, 1910, **5**, 622–670.
[6] White, P. R., *Zeitsch. f. Zellforsch.*, 1928, **7**, 673.

Vivipary in Sorghum.

THE phenomenon of Vivipary, *i.e.*, the germination of the seed *in situ*, though rare, is not uncommon in the Angiosperms. It is not so common in the Gramineæ and is rare in cereals. Two cases are on record in cereals, both in Maize (Eyster, 1924).[1,2] Eyster calls these "primitive sporophytes". He notes that this character is heritable behaving as a simple recessive to the normal dormant condition. He finds that two independent factors, pm_1 and pm_2, are responsible for this vivipary.

In higher plants when the earhead is ripe the embryo stops its growth and lies in a dormant state. The endosperm remains practically unused. This cessation of growth

seems to be maintained very largely by an insufficient water supply.

In sorghum, an instance in which the embryo failed to go into the usual quiescent state has been met with. This occurred in *Sorghum papyrascens*, Stapf., M. S. 1401, a variety from the Central Provinces. *S. papyrascens* is like the other grain sorghums, *S. Durra*, Stapf. in practically every respect except that in it the glumes are long, thin, papery and transparent and do not have the usual keel clasping the grain. This kind of glume is more akin to the primitive condition represented by the absence of coriaceousness in the glumes of pedicelled spikelets. This *papyrascens* glume seems therefore to be a mutational manifestation of the normal glume. When this primitive type of glume occurs alone and without any other consequential changes, the usual sexual equipment ending in the normal big *Durra* grain, seems to receive an upsetting of the usual balance between the container and the contained. The *Durra* grain instead of being clipped up tightly below by thick, coiraceous glumes leaving a good bit of the grain exposed, now finds itself loosely and completely enclosed by the long, papery glumes. This mis-fit has its repercussions on the normal development of the lodicule and the consequent upsetting of its rôle as the regulator in the opening of flowers. The net result of this *papyrascens* mutant is a normal plant with an uneconomic earhead having a considerable amount of sterility in it.

The occurrence of this vivipary in one variety of this group of *S. papyrascens* is therefore understandable. A primitive type of glume has brought out this primitive endeavour at short circuiting the plant's life cycle. Family No. A. S. 149, in which a chlorophyll deficiency resulted in the production of pale green seedlings, belongs to the *papyrascens* group (G. N. Rangaswami Ayyangar and M. A. S. Ayyar, 1932).[3] Albinos have been noted by Eyster in his primitive sporophyte in maize. It will therefore be seen that papery glumes, vivipary, and chlorophyll deficiencies are of the bunch of residuary defects brought about by this mis-fit.

An examination of the seeds in the earhead manifesting vivipary showed that about 75 per cent. of the grains had germinated. Photographs of a viviparous grain (Fig. 1) and of twelve other grains in various stages of germination (Fig. 2) are given. It was suspected whether any particular position in the earhead stimulated this vivipary but an examination of the earhead, whorl by whorl, showed a fairly even distribution in its occurrence. Various endeavours were

Fig. 1.
× 8.

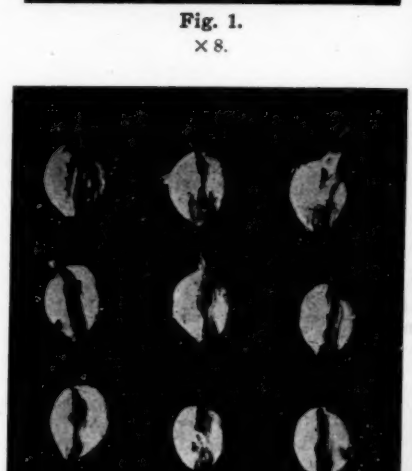


Fig. 2.
× 2.

made to germinate the seed but with only a single success. Even in this case the seedling died after a feeble endeavour at growth.

The genetic factors responsible for this occurrence of vivipary in Sorghum are under examination.

G. N. RANGASWAMI AYYANGAR.
V. PANDURANGA RAO.

Agricultural Research Institute,
Coimbatore,
April 22, 1935.

1 *Amer. Jour. Bot.*, 1924, **11**, 7.
2 *Amer. Nat.*, 1924, **58**, 436.
3 *Ind. J. Agri. Sci.*, 1932, **2**, 266.

On the Nature of the Papaghni-Cheyair Sequence.

IN describing the "Kadapah and Karnul formations in the Madras Presidency", King[1] believes in the existence of an unconformity between the Papaghni and the Cheyair divisions of the lower Cuddapahs. Recently however Dr. A. L. Coulson who examined these formations in connection with the occurrence of Barytes and Asbestus in this area, contends that this unconformity does not exist or "if it exists at all, is so small as to be negligible".[2] In all the places where King has noticed an unconformable junction, Coulson believes that the quartzites overlying the Papaghnis are *not* the Pulivendla quartzites of the Cheyairs but belong to the Banganapallis, the basal member of the very much younger Kurnool formation. While this explanation may be true in some cases, we cannot believe that it is of universal application throughout the Papaghni-Cheyair area. We have recently had opportunities of examining many localities where we see the Papaghni-Cheyair junction and have made several observations which go to support King's conclusion regarding the existence of an unconformity.

(1) In several places as for instance at Vaimpally (14° 25′ 30″ : 78° 14′), Chandana (15° 5′ : 77° 49′) and Balapalapalle (15° 27′ 30″ : 78° 6′ 30″), we see the Vaimpally shales and limestones (Papaghni) overlaid by the quartzites which are admittedly (even by Coulson) of the Pulivendla (Cheyair) subdivision. In all these places, the quartzite begins with a coarse conglomeratic facies containing, among others, pebbles of oolitic chalcedony or chert. According to King "these contained fragments of oolitoid siliceous chert are common to the lowest breccias and conglomerates of nearly the whole extent of the western outcrop of the Pulivendla quartzites". These pebbles could have been derived only from the chalcedonic bands with oolitic structure, which we know are exclusively confined to the Vaimpally limestones—thus showing distinctly that the latter must have started being denuded prior to the deposition of the conglomeratic quartzites. (2) Moreover the quartzites immediately above the conglomeratic zone in all the three localities show such evidences of shallow-water deposition as current-bedding, ripple-marks, etc., and could not have been deposited at depths of more than 8-10 feet—thus indicating the proximity of the shore line. (3) If according to Coulson the Papaghni-Cheyair sequence were unbroken, one would have expected to see a gradual grading of sediments from the Vaimpally shales or limestones to the pure quartzites above. We are not aware of any such occurrence—the transition from the lower to the upper series being always abrupt and well defined. (4) Another evidence pointing to the existence of a Papaghni-Cheyair unconformity is seen near Donakonda (2 miles east of Nayanapalli). Here we see the shales and limestones of the Vaimpally sub-division have a strike 20° west of north and dip 10° east, while the overlying Pulivendla quartzites strike 45° west of north and dip 20° east—distinctly suggesting an angular unconformity.[3] (5) From our study of the trap rocks seen between the Papaghnis and the Cheyairs near Talapalli (5 miles west of Vaimpally) we have reasons[4] to believe that this trap flow is "sub-aerial" and not "sub-marine". The sub-aerial character of this lava flow which overlies the Vaimpallys and underlies the Pulivendlas must naturally lead one to infer an unconformity between the two divisions.

From what has been said above, it appears to us that the unconformity between the Papaghnis and the Cheyairs is not so 'negligible' as Coulson suggests.

C. PRASANNAKUMAR.
M. R. SRINIVASA RAO.

Department of Geology,
Central College, Bangalore.
May 29, 1935.

1 *Mem. G.S.I.*, **8**, pt. 1.
2 *Mem. G.S.I.*, **64**, pt. 1, pp. 3 & 6.
3 *Geologic Structures*, B. & R. Willis, p. 44.
4 These will be discussed in a separate paper on the trap rocks of the lower Cuddapahs to be published shortly.

The Arc Spectrum of Iron in the Photographic Infra-Red Region.

By Dr. Muhammad Zaki Uddin.

Fellow, Alexander von Humboldt-Stiftung (Berlin), Physical Laboratories, Bonn.

THE production of the new photographic Infra-Red plates on a commercial scale has made accessible spectral regions up to about γ 13,000, that can now be investigated with spectroscopic accuracy. This unexplored region involves the necessity of having suitable standard lines that could be employed in other direct and indirect calculations.

The use of the Iron Arc and the various conditions under which it has to be employed are too well known to be mentioned here; and the adoption of this Arc for the Photographic Infra-Red region seems probably inevitable. A number of investigations have been made from time to time with the Iron Arc and some measurements on the Solar lines are also available. Although the early investigations were hampered due to the difficulties in the technique of photographing this region, some progress has been made; I give below a short summary of the previous work carried in this direction:

Burns[1,2,4] published his measurements on the Arc Spectrum of Iron using the grating and gave wavelengths up to λ 8825. Along with it the Interferometric measurements are also available for the Arc up to the same region[3].

A list of Red and Infra-Red lines of Iron was published by Meggers and Kiess[4a] giving data up to λ 10,375.

Randall and Barker[4b] gave observations of the Iron Arc extending to λ 26,727 with Infra-Red Spectroscopic arrangements.

Meggers and Kiess[5] measured lines of Iron Arc till λ 8825.

A list of Solar lines was published by Babcock[6] and also by Meggers and Brackett containing measurements with the Interferometer up to λ 9000. Unfortunately the solar radiation cannot be employed in the laboratory as a convenient source due to many difficulties.

Babcock[7] gave his Interferometric measurements of Neon and Iron lines up to λ 7585.

In the meeting of the International Astronomical Union held at Leyden in 1928, Iron and Solar radiations[7a] were adopted for further use till λ 8825 and these have been slightly altered recently.[12]

Measurements of Iron lines are available after Burns and Walters[8] till λ 9653.

Querbach[9] measured the arc spectrum of Iron up to λ 8866.

The lines were measured by McLennan and Quinlan[10] till λ 9000.

Meggers and Kiess[11] gave measurements of Iron lines till λ 10,863.

Schmitz[13] measured the Iron lines till $\sim\lambda$ 9000.

Recently Dingle[14] has published the wavelengths of Iron lines up to λ 10,218 "which cannot be used as final standard".

Using specially sensitized plates Meggers[15] has investigated the Arc Spectrum of Iron till $\sim\lambda$ 12,000 and this is probably the first thorough investigation so far available.

From time to time attempts have been made to compile a list of wavelengths available for the Iron Arc lines in this region.

Catalan[16] published a number of Iron lines in tabular form and Kayser and Konen[16a] have compiled a list of the lines.

Schmitz[13] gave a comparison table of some of the wavelengths in his dissertation.

The new volume of the *Handbuch der Spectroscopie*[17] contains a detailed account and discussion of the Iron lines in the Visible and Ultra-Violet

Arc Spectrum of Iron—Some Intense Lines.
(*Meggers.*[15])

Int.	λ(air)	Int.	λ(air)
250 ..	7164,469	1500 ..	8220,406
800 ..	7187,341	1200 ..	8327,063
500 ..	7207,406	1200 ..	8387,781
400 ..	7495,088	300 ..	8468,413
800 ..	7511,045	600 ..	8661,908
300 ..	7780,586	1500 ..	8688,633
400 ..	7832,224	250 ..	8824,227
700 ..	7937,166	200 ..	8999,561
600 ..	7945,878	100 ..	9738,624
700 ..	7998,972	30 ..	10065,080
600 ..	8046,073	40 ..	10145,601
500 ..	8085,200	50 ..	10216,351

1 K. Burns, *Liek. Obs. Bull.*, 1913, **247**, 8, 27.

2 K. Burns, *Z. f. wiss. Phot.*, 1913, **12**, 207.

3 K. Burns, *C.R.*, 1913, **156**, 1611; *J. de Physique*, 1913, (5) **3**, 457.

4 K. Burns, *Fortsetzung Z. f. wiss. Phot.*, 1914, **13**, 235.

4a W. F. Meggers and C. C. Kiess, *Sci. Pap. Bur. St. Nr.*, 1918, 324.

4b H. M. Randall and E. F. Barker, *Ast. J.*, 1919, **49**, 42.

5 W. F. Meggers and C. C. Kiess, *Sci. Pap. Bur. of St. Nr.*, 1924, **479**.

6 H. D. Babcock, *Ast. J.*, 1927, **65**.

7 H. D. Babcock, *Ast. J.*, 1927, **66**, 256.

7a *Trans. International Astronomical Union*, 1928.

8 K. Burns, *Pubs. Alleg. Obs.*, 1930, **6**, 159.

9 J. Querbach, *Z. f. Phys.*, 1930, **60**, 109.

10 J. C. McLennan and F. M. Quinlan, *Trans. R. Soc. Canada*, 1930, **24**, part I, 47.

11 W. F. Meggers and C. C. Kiess, *J. Research*, 1932, **19**, 309.

12 *Trans. International Astronomical Union*, 1933.

13 L. Schmitz, *Diss.*, Bonn., 1934.

14 H. Dingle, *M. N. R. A. S.*, 1934, **94**, 866.

15 W. F. Meggers, 1935 (In Press); *J. Research*, 1935, **14**, 33.

16 Catalan, *Annales de la Soc. Esp. de Fis. y. Quin.*, 1930, **28**, 1239.

16a H. Kayser and H. Konen, *Handbuch der Spectroscopie*, 1932, Bd. **7**, 1239.

17 H. Kayser and H. Konen, *Handbuch der Spectroscopie*, Bd. **9** (in Press).

regions. A list of lines is also given for the near Infra-Red region.

Plates of the Iron Arc Spectrum till λ 8824 are available after Meggers and Kiess[5] and Dingle has given a photograph till λ 10,218.

The members of the International Astronomical Committee are considering the question of the Iron Standard lines in this region and very soon standard wavelengths will be available.

My thanks are due to Prof. H. Kayser and Prof. H. Konen for making their excellent libraries accessible to me and encouragement.

Research Notes.

Moments of Hypergeometric Series.

A. A. KRISHNASWAMI AYYANGAR obtains a general expression involving determinants for the moments of the Hypergeometric series about its mean (*J. Ind. Math. Soc.*, 1934, **1**, 4). The author considers his formula to be more useful than the one given by Romanovsky (*Biometrika*, Vol. XVI) for the first six moments. The author also gives a recurrence formula for evaluating his determinants for higher moments.

In the same number of the Journal Brij Mohan Mehrotra has a short note on "Some Self-Reciprocal Functions," in which he formulates some corollaries of theorems published by him previously.

Ram Behari discusses an integral invariant connected with rectilinear congruences. Considering the ruled surface $\xi = x + uX$, $\eta = y + uY$, $\zeta = z + uZ$ where (x, y, z) denotes a point on a closed curve, the invariant considered is $p = \int_c (Xdx + Ydy + Zdz)$. Several interesting properties of p and $\frac{dp}{d\bar{s}}$ are discussed.

Artificial Radioactivity produced by Neutron Bombardment.

IN the *Proceedings of the Royal Society*, 1935, **149**, 522, Fermi and his collaborators have given a description of a further instalment of their interesting experiments on artificial Radioactivity. Having noticed that the activity produced by neutron bombardment is profoundly influenced by hydrogenated substances, they have systematically studied the effect of water on the activity of all the newly-produced radio-elements. There are some cases in which the activity is largely influenced as, for instance, Na, Al (2·3 m.), V, Ag, Cu, Rh and I; in others the influence of water is very small as in the case of Si, Al (10 m.), Mg, Mn and Zn. In every case in which the active element is known to be an isotope of the bombarded one (about 20 instances), they find that the activation is increased by the presence of water. This result is explained by assuming that the slowing down of the neutrons by the protons contained in the hydrogenated substances makes it easier for these neutrons to be captured by the struck nucleus. In order to verify this hypothesis experiments were made to determine the absorbing power of various materials for slow neutrons and they found that the absorption was abnormally high in some instances as B, Y and Cd. Except in these cases of abnormal absorption it was found that each absorbed neutron produced one activated nucleus; the abnormal absorption is probably connected with the formation of stable isotopes. The mean energies of the activating neutrons have also been measured and all the results are given in a table at the end of the paper. The effect of non-hydrogenated substances is also to increase the activation by slowing down the neutrons but the effect is not so intense as in the case of hydrogenated substances. Another important result due to the new investigation is the conclusion that when a new radio-element isotopic with the struck nucleus is produced, the new nucleus is of higher atomic weight and results from the capture of the neutron. The separation of the radio-active isotope from the bulk of the bombarded element was also found possible since the activated molecules are left in an atomic or ionic condition. The method was employed in the case of bromoform, chloroform, carbon tetrachloride and sodium chlorate, to separate radio-active bromine and iodine. Radio-active arsenic was obtained from cacodylic acid and radio-active manganese from potassium permanganate. A systematic investigation of all the elements revealed a number of new facts both as regards the induced activities and the properties with respect to slow neutrons; all these are consolidated in a useful table at the end of the paper. The authors have also carried out new chemical tests on the products obtained by bombarding uranium and find further support for their previous claim about the production of transuranic elements. They

conclude that the 15 sec., 13 min., and 100 min. activities are due respectively to products with atomic numbers 92, 93 and 94 and atomic weight 239.

T. S. S.

Masses of Some Light Atoms.

AN accurate determination of the masses of some of the fundamental particles such as the proton and the neutron is a most important necessary preliminary work in a programme seeking to elucidate the nature of these particles. The values obtainable by considering the results provided by the mass-spectrograph and those deduced from considerations of the masses and energies of the particles taking part in a nuclear encounter seemed to be in conflict. But recently Aston has been constructing a new mass-spectrograph designed to study the masses of (light) atoms by comparing the positions of close doublets such as O and CH_4, C^{++} and D_3 etc. and has reported the result of some preliminary measurements in *Nature*, 1935, **135**, 541. The values he obtains are much higher than those previously given by him and the difference he attributes to imperfect resolution in his older instrument. The new values are in agreement with those deduced by Oliphant, Kempton and Rutherford (*Proc. Roy. Soc.*) from a consideration of a number of nuclear reactions, particularly those arising when beryllium and boron are bombarded by deutons. According to the new estimates, the mass of the neutron is slightly larger than that of the proton, but not so high as 1·0092 as estimated by Curie and Joliot. Possibly Wentzel's conclusion that the mass of the neutron is equal to that of the hydrogen atom is near the truth. The following table gives a comparison of the values found by Aston and those estimated by Oliphant, Kempton and Rutherford:—

	Aston	Oliphant *et al*
$_0n^1$	..	1·0083±0·0003
$_1H^1$	1·0081	1·0081±0·0001
$_2He^4$	4·0041	4·0034±0·0004
$_6C^{12}$	12·0048	12·0027±0·0003

T. S. S.

Absolute Rates of Migration of Ions.

THE moving boundary method for the determination of the transference numbers of ions is reliable only if the potential gradient under which the ions move is accurately measured. Mukherjee and his co-workers (*J. Indian Chem. Soc.*, 1935, **12**, 177) have developed a method for the accurate determination of the migration velocity of ions, involving a technique similar to the measurement of the cataphoretic speeds of colloidal particles as described by Mukherjee (*Proc. Roy. Soc.*, 1923, A **103**, 102). Considering the boundary between hydrochloric acid solution and picric acid, it has been shown that with the movement of the ions under a potential gradient, the migration of the picrate ion increases with time while that of the chloride ion decreases. Though the boundary remains sharp during the interval of the observations, it has been shown that a slight mixing up of the solutions may account for large variations of the mobilities. Hence the initial migration velocity of the ions before mixing takes place with simultaneous measurement of the potential gradient across the boundary gives reliable values.

M. P. V.

Krypton Content of Atmospheric Air.

THE literature on the quantitative estimation of Krypton and Xenon in the atmosphere is very scanty. Sir William Ramsay, the pioneer research worker in rare gases of the atmosphere, published an estimate of the Krypton concentration (*Proc. Roy. Soc.*, 1900, **67**, 329) and gave a value of 1×10^{-6} which was later on corrected to 5×10^{-8} and still another correction was made in a subsequent paper. His method was fractional distillation. Moureu and Lepape adopted the method of fractional adsorption on cocoanut charcoal and estimated by spectro-photometric examination of Krypton line in a "Plucker" discharge tube and gave the value of $1 \cdot 31 \times 10^{-4}$ Krypton : argon (parts by volume).

Dr. Brody and Dr. Körösy (*Trans. Faraday Soc.*, 1935, **31**, 547) adopted a purely chemical procedure for the separation of the rare gases of the atmosphere, avoiding all doubts arising from fractional distillation or adsorption, obtained spectrograms of emission in an electric discharge and determined the relative intensity of the spectrum lines of Krypton in relation to some of the weaker argon lines. A series of argon-Krypton mixtures of known composition were prepared, the relative intensities of the same lines determined and the Krypton content of "air argon" calculated by interpolation. They arrive at the value of $1 \cdot 6 \times 10^{-4}$ Krypton:

argon. The argon content of air being 0·935 per cent. by volume, the Krypton content is $1{\cdot}5\times10^{-6}$ volume parts (*i.e.*, $1{\cdot}5\times10^{-4}$ per cent. by volume) the most accurate value up to the present as claimed by the authors.

K. S. R.

Chemical Composition of Root-Rot Affected Peas.

CHARACTERISTIC differences in the chemical composition of peas affected with root-rot as compared with peas from healthy plants are noted and discussed by Kertesz, Horsfall and Rouse in the *Journal of Agricultural Research*, Vol. 49, No. 9. The root-rot under reference is not due to any single organism but a complex comprising *Pythium* Spp. and *Rhizactonia solani* Kuhn. The striking difference in outward appearance, is the decidedly larger size of the affected peas in really all stages of ripeness, due, it is suggested, to the quicker translocation of Carbohydrates into the ovules. The injured root system seems to curtail the water, nitrogen and ash supply, which results in the setting of peas with a lower water-content and a lower ash and nitrogen contents in the dry matter.

A. K. Y.

Plant Growth as Influenced by the Deficiency of Available Soil Manganese.

CHLOROSIS associated with insufficient available manganese in the soil has been studied by B. E. Gilbert and the results of several years' experiments connect definitely Mn chlorosis with soil alkalinity (*Rhode Island Sta. Bul.*, 246). In the soils studied the critical range seemed to lie between PH 6·8 and 7·6, though it could not be linked with soil type. Crops differed greatly in their susceptibility. In certain cases Mn deficiency resulted in decreased yield without visible chlorotic symptoms.

Spraying the plants with sulphate of manganese at the rate of 8 lbs. per acre afforded a ready means of correcting the defect, as likewise in the alternative by manuring with the sulphate at the rate of 30 lbs. per acre; the effects of the manure did not persist, however, for more than a year as a corrective. Manuring with sulphate of ammonia or other means of counteracting the effect of excessive liming also acted as a preventive (abstracted from the *Expt. Stn. Record*, January 1935).

A. K. Y.

The Sugar Content and Odour of Clarified Extracts of Plants as related to Their Susceptibility to Insect Attacks.

INVESTIGATIONS tending to show that the susceptibility to attacks by the Japanese beetle (*Papillia Japonica* Newm.) is more in plants, the clarified extracts from which are low in their content of reducing sugars and which possess a fruity odour than in those whose extracts show a higher sugar content and possess no such fruity odour, are described by Metzger, Van der Meulen, and Mell in the *Journal of Agricultural Research*, Vol. 49, No. 11. The plant extracts were mostly from leaves, and with ethyl alcohol, the clarification being effected by lead acetate; the investigations related to 97 species and varieties of plants. The extent to which plant extracts of various kinds can act as an attractant or as a repellent affords a study of much economic value in combating insect pests either by the method of baiting and destroying or by that of keeping them off, and it will be a fruitful line of work if a study with this subject should be systematically undertaken in regard to crop pests of this country.

A. K. Y.

Kiln Drying of Wood with Ozonized Air.

THE use of ozonized air for kiln-drying of wood has been advocated, particularly in France, as it is claimed to give better results than the usual methods. The addition of a small quantity of ozone to the air has been supposed to accelerate and facilitate seasoning, especially in the case of refractory timbers. It has also been claimed that ozone-dried timber suffers less from seasoning defects and is less susceptible to atmospheric influences. In his little book of twenty pages, Mr. Kapur (*Indian Forest Records*, Economy Series, Vol. XX, Part XIII) describes the experiments carried out by him at the Forest Research Institute, Dehra Dun, on the kiln-drying of various species of Indian timber with ozonized air. Experiments with and without ozone carried out under otherwise identical conditions showed conclusively, that from the practical point of view, kiln-drying with ozonized air has

absolutely no advantages over the usual methods. In fact, the idea that ozonized air has any beneficial effect in seasoning wood is proved to be more or less a superstition.

C. V.

The Dutch Elm Disease.

A. W. McCALLUM, Forest Pathologist, has described (Pamphlet No. 159, New Series, Department of Agriculture, Canada) a fungus disease affecting the elms in the United States since 1930. Elms are commercially important in Canada and generally rank fourth among the hard-woods in regard to annual production. It is also one of the most valuable ornamental trees valued for its rapid growth, attractive form and moderate shade.

Sudden wilting and yellowing of leaves is one of the most characteristic external symptoms. The leaves get shrivelled, and become brittle and the disease, particularly in the case of big trees, may be confined to one or two branches at the commencement. Diseased trees often produce vectors along the main stem and the bases of large branches.

Internal symptoms consist of a broken or complete ring of brown dots in the cross-section of the sap wood. A longitudinal section will reveal brownish streaks varying in number according to the roots as well.

The fungus (*Graphium Ulmi*) is principally spread from tree to tree by means of spores adhering to the bodies of elm bark beetles and is also wind-borne. Control measures consist of decapitation of affected limbs in the case of partially affected plants but if the main stem is affected, nothing can be done to save the tree. To prevent the fungus from spreading to healthy trees, it is necessary to destroy those already infected. It is hoped the enforcement of such extreme control measures, if taken early enough, may result in the total elimination of the fungus.

M. S.

Rôle of *Tabanus Orientis* Wlk. and *Stomoxys Calcitrans* Linn. in the Mechanical Transmission of Rinderpest.

RINDERPEST being the most common and fatal of epizootics in India any addition to the existing knowledge of this dire disease is most welcome. Bhatta has reported the results of his experiments to find out if *Tabanus Orientis* Wlk. and *Stomoxys Calcitrans* Linn. are incriminated in the transmission of this disease (*Indian Journal of Veterinary Science and Animal Husbandry*, 1935, **5**, Part I). The experiments which were very carefully conducted have proved that *T. Orientis* can transmit the disease under natural conditions from the infected to healthy cattle although *S. Calcitrans* was found to be incapable of doing so. It had been known that *Glossina morsitans* was a confirmed vector of the disease in Africa. The present experiments have conclusively shown that *Tabanus* is involved beyond doubt in the transmission of the disease in India. The writer suggests further experiments with other species of biting and non-biting flies in order to conclude which of them are probable vectors so that necessary control measures may accordingly be adopted to check the spread of Rinderpest among bovines in this country.

S. D. A.

The Diet and the Brain in Fishes.

B. S. BHIMACHAR (*P. R. S.*, Series B, 1935, **177**) has pointed out some interesting correlations between the feeding habits and the structure of the medulla oblongata in the South Indian Cyprinoid fishes. These fishes, according to their feeding habits, can be divided into two main groups—1. those which feed by taste, and 2. fish which feed by sight. In the former group the fishes are bottom feeders and the taste buds in pharynx (Lepidocephalichthys) or on the barbels and the snout (Nemachilus) are responsible for sorting out food and correspondingly their nerve centres in the brain, either the vagal or the facial lobes, are very well developed in these forms. In the sight feeders (Rasbora, Nauria, Danio and Chela), the vagal and the facial lobes are very small and there is a well-developed central acoustic area or lobe.

The Brain of Gadus.

AN important contribution to our knowledge of the piscine brain has been made by H. Muir Evans (*P. R. S.*, 1935, **177**), in his paper on the brain of Gadus. In the first part of the paper he describes in detail the medulla oblongata of the Whiting (*Gadus merlangus*) and compares it, with serial

sections of the corresponding regions, with that of the Roach. An attempt has been made in the second part to correlate the structure of the hind brain with the feeding habits of different Gadidæ.

The author lays considerable stress on the existence of true facial lobes in Gadidæ since their presence in these forms has been denied by previous workers. It has been stated that, while identifying the various lobes of the brain, important consideration has to be given to their histological structure in addition to the nerve trunks and their associated tracts. The somatic sensory area or the 5th lobe is very prominently developed in the predacious members of the Gadidæ, while the facial lobes are well developed in the forms which feed on crustaceans, molluscs and worms. The dentition is also modified according to the nature of the diet.

Basic Xenoliths and their Grain-size.

DURING recent years a large volume of literature has developed dealing with the various aspects of the basic xenoliths, but few people have attached any importance to the apparent relationship between the grain-size of the xenolith and that of the host rock. This problem has been lately studied by Miss Joplin of Cambridge (*Geological Magazine*, No. 851, May 1935). She has made a detailed study of the xenoliths and their grain-size, and depending upon the work of such well-known petrographers as Nockolds, Tilley and Campbell Smith, she has come to the conclusion that in most cases xenoliths are more fine-grained than the host rock. This discrepancy is brought about by recrystallisation and hybridisation in rocks. Under the influence of thermal metamorphism, large mineral individuals are broken up into smaller granular units, thus bringing about a reduction in grain-size. Similar effects are produced in metamorphic rocks where poikilitic structure is so common. Discussing the case of hornblende in this connection, she has suggested that when criss cross flakes of biotite are developed it leads to a finer texture. Further it is interesting to note that at a late stage in the hybridisation of rocks, hornblende becomes so highly poikilitic that disruption is imminent, and a slight movement of the magma is sufficient to produce a fine-grained aggregate.

Science Notes.

Paraffin Films in the Study of Infra-red Absorption Spectra.—Drs. N. R. Tawde, Y. G. Naik and D. D. Desai, of the Royal Institute of Bombay observe :—" Great difficulty generally presents itself in the preparation of paraffin windows for absorption chambers in the infra-red work. Essential factors in preparing a proper film are (i) the homogeneity of the film, and (ii) the thickness of the film.

" While studying the experimental technique of infra-red absorption measurements, we tried various methods of preparing such films. The process of preparing a film on the water surface was rather easy, but it had the following defects : (*a*) The film was not of uniform thickness, (*b*) it cannot be made very thin, for in doing so, it gets perforated, and (*c*) it is not homogeneous throughout, for there is every chance of water vapour remaining embedded within the film, thereby increasing the absorption of the infra-red radiation. After enclosing the HCl gas for about 24 hours in a chamber closed with this film, minute acid drops were formed on both sides of this film, showing that it was permeable to HCl gas for the thickness desired. It was therefore best if the films were quite free from any traces of moisture.

" M. Czerny (*Zeit. f. Physik*, 1927, **44**, 235) and L. Kellner (*Zeit. f. Physik*, 1929, **56**, 215) have described a method of preparing this film by pouring paraffin on a plate of glass which was previously heated, and on which, a thin membrane of celluloid was spread. The film was taken out by removing and breaking off the celluloid membrane. The thickness of the film thus obtained was rather high, *i.e.*, 1.2 to 1.5 mms. or even more.

" During our experiments, we thought of preparing the film by spreading paraffin on a clean surface of mercury which was kept at a suitable temperature. The advantages of using this method are found to be the following : (*a*) no trace of water will interfere ; (*b*) the film is of uniform thickness throughout ; (*c*) the film of any desired thickness can be formed ; and (*d*) the film is not permeable to HCl gas or air. There is not the slightest trace of moisture on the outside surface.

" In order to test the homogeneity and uniformity of the thickness of such films, we have examined the absorption for heat rays, of the films prepared both on water and mercury surfaces. These were obtained with thickness within the desired range and examined for absorption at various sections of their area under identical conditions. The mean value of percentage absorption was determined in each case. The deviation of various readings from the mean showed that for the thickness desired for the purpose of these experiments, the paraffin films prepared on mercury surface give, on the whole, better results than those prepared on water surface. This can be verified from the following which is typical of the different sets of readings taken."

Film prepared on surface of	Thickness of the film	Mean % absorption	Deviation from the mean	
			Max. %	Min. %
	mm.			
Mercury ..	0.375	73.402	0.1771	0.1635
Water ..	0.55	76.88	0.43	0.26

* * *

Notes on "A study in the mode of pollination, in Portulaca quadrifida *Linn."*—Mr. S. Ghose, St. Xavier's College, Calcutta, writes :—"While making a study of the physiological causes of the movement of the petals and leaves of *Portulaca quadrifida* L., I observed that the pollination of the flowers of the plants under observation showed a very interesting change in their mode of pollination. The pollination of the flowers of *Portulaca grandifolia* Lindl. and *P. oleracea* Linn., was studied by De Bonis (*Rir. fis. mat. Sc. nat.*, Pavia, 1893) and Kerner (*Nat. Hist. Pl. Eng. ed.* 1,11,395) respectively and they found the flowers of these plants to be either partially or wholly *cleistogamous*.

"The flowers of *Portulaca quadrifida* L., however, show a very interesting change in their mode of pollination. The terminal portion of the axis on which the flowers grow is cup-shaped, inside which the flowers remain concealed, surrounded by four terminal opposite leaves. In continuous deep shade or in darkness the flowers do not open, but remain enclosed in the fold of the leaves, thus ensuring *cleistogamy*.

"But in course of this study, I found the following facts which distinctly indicate *chasmogamy* or cross-pollination. (1) Flowers always terminate a vertical branch. (2) Flowers though very small are made conspicuous by their large numbers, bright yellow colour of the petals, and all blooming at a time. (3) As the day advances the flowers emerge out of the cup-shaped axis and the folds of the leaves and place themselves quite exposed. (4) An average of about two hundred readings shows that light and water supply being sufficient the flowers all open between 10-45 A.M. and 11 A.M. and remain open for about 2 hours and 25 minutes. (5) The style is longer than the filaments of the stamens. (6) Serial sections of some freshly opened flowers showed no sign of pollination. (7) Ants, flies and sparrows are found to visit the plants when the flowers remain open.

"Study of the above facts show that the pollination in *Portulaca quadrifida* L., is dependent on external conditions, such as light, temperature and humidity.

"A complete paper will be communicated elsewhere."

* * *

A Note on Microspore-formation in Melosira varians *Ag.*—Mr. M. Abdul Majeed, Botany Department, Government College, Lahore, writes :—"Microspore-formation has been studied in *Melosira varians* Ag. at its natural habitats in Lahore and its vicinity and experiments have also been performed to produce it culturally in the Laboratory.

"Although the Knop's solution did not give much satisfactory results with this Diatom, the writer, however, was successful in cultivating it on the solid media of Agar Agar. (Method employed by Richter-Rein Kulturen von Diatomeen, 1906).

"The long filaments within a period of 8–10 days broke up into single individual frustules, and the inner contents of the protoplast by numerous successive divisions formed 8–16 or more protoplasmic bodies (microspores), each 4–6μ in diameter. These naked cells later on emerged out of the frustules after about a fortnight or so and then developed new siliceous walls."

Birthday Honours :—

Knighthood.—Dr. L. L. Fermor, O.B.E., D.Sc., F.G.S., F.R.S., Director, Geological Survey of India. *C.I.E.*—Lt.-Col. R. Knowles, I.M.S., Professor of Protozoology and Secretary of the Calcutta School of Tropical Medicine. *Dewan Bahadur.*—Rao Bahadur L. K. Ananthakrishna Ayyar, B.A., L.T. *Rao Bahadur.*—Mr. M. Vaidyanathan, M.A., L.T., F.S.S., Statistician, Imperial Council of Agricultural Research. *Rao Sahib.*—Dr. T. V. Ramakrishna Ayyar, Entomologist, Agricultural Research Station, Coimbatore.

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Wind Data for Wind Mills. By V. Doraiswamy Iyer, B.A., *Scientific Notes*, India Meteorological Department, **6**, No. 63. Pp. 57-85.—Monthly normals of wind velocity for 205 observatories in India and a few stations in the neighbouring countries are given and the distribution of wind velocities in the different seasons is illustrated by charts. Curves of the diurnal variation of wind velocity at 22 stations for the four seasons are given. Tables giving the frequencies of occurrence of winds of different speed ranges, and of days with different total duration of wind-speeds exceeding 6 miles per hour which is considered the minimum for working a wind mill for agricultural purposes, have also been prepared for fifteen stations. The data presented are briefly discussed.

* * *

Chromium Steels.—[His Majesty's Stationery Office, Price, (Post Free) 8*s*.]. This book presents a comprehensive review of published information on the plain chromium steels, and gives a detailed account of their history, constitution, mechanical and physical properties. The uses of plain chromium steels (structural steels, case hardening steels, steel castings, gauges and dies, ball bearings, rails, valves, etc.) are also dealt with and some hitherto unpublished work carried out at the Research Department, Woolwich, is described. The treatment of the subject will make the work of interest and value to metallurgists and engineers.

* * *

The Cadak Festival.—In a paper presented before the Asiatic Society of Bengal, at an ordinary meeting held on the 3rd June, Mr. K. P. Chattopadhyaya described a festival observed in Bengal, called the Cadak festival, which is associated with the vernal equinox. The ceremony begins a week before the end of the month of Caitra (March–April) and culminates on the last day of that month, which also marks the close of the year in Bengal. This date is known

as the day of the passing of the sun into Aries (Mahāviṣuva saṃkrānti). Actually it comes after the day of the vernal equinox by about three weeks. The name, however, indicates clearly the association with the equinoctial day which once did coincide with this date. The end of the year in Bengal appears in course of time to have lagged behind to this extent. The traditional origin of the festival is that on this date king Vāṇa in order to please Mahādeva, drew blood from his body as an offering and propitiated him by dances (along with friends) which are favoured by him.

* * *

Gold Deposits in Trichy.—It is understood that Mr. Naraindas Girdharidas has taken prospecting mines' lease for exploiting auriferous quartz, carrying pyrites and gold, with horn blende and mica schist. The mines have been tapped in a village in Kulitalai Taluk, Trichy District. The veins running across cover an area of 3 square miles.

* * *

Glass Manufacture in Hyderabad.—The Department of Commerce and Industries has recently given a fillip to the work of reviving old industries by starting a glass factory in the suburbs of the Hyderabad City. The factory has been equipped with up-to-date plant and is located close to a range of hills rich in quartz.

The manufacture of paints and varnishes has also been started, and it is hoped that very soon the State will be able to supply her local needs. It may be mentioned that, at present, the total imports exceed ten lakhs of rupees.

* * *

Fruit Cultivation in Hyderabad.—The Imperial Council of Agricultural Research has recently given a grant to the Agricultural Department for carrying on research work on grapes and custard apple. The activities of the Agricultural Department in the development of fruit cultivation have recently been intensified with the result that keen interest has been aroused in the farmers. An extensive survey of the fruit growing industry has already been made and in the Aurangabad District, which is reputed to be the best fruit growing area in the State, experimental gardens have been established at Himayatnagar, Sangareddi, Parbhani, Warangal and Raichur. Training classes have been started in the experimental farms where students receive instruction in the scientific methods of fruit culture.

* * *

In the course of an address on the future of sugar industry in India delivered before the Royal Society of Arts, London, Mr. B. C. Burt, Agricultural Adviser, Imperial Council of Agricultural Research, said that the season 1935–36 will see about 145 modern factories in operation with an estimated combined capacity of 810,000 tons of sugar annually. For further expansion in Northern India there is little room. The development in the south will be gradual. There is great scope for factory sugar, and this can be seen from the fact that for the quinquennium ending 1931, the average consumption was 961,000 tons. The sugarcane crop which is an all-times crop has given the Indian cultivator a relatively large income for his labour and employment throughout the year; by closer co-operation between the factories and growers, the future of the Indian Sugar Industry will be assured.

* * *

Preparation of Sugar Syrup from Cashew Apple.—The Department of Industries, Madras Government, have during recent years taken keen interest in the development of cottage industries. Recently they organised a demonstration at Mangalore on the preparation of sugar syrup from cashew apple, a fruit which is now being exploited mainly for the cashew nuts. The juice that can be extracted from the pulp contains about 10 per cent. invert sugar. But the tannins, phenols and other unknown constituents of the fruit juice render it unsuitable for use. Besides, the juice perishes very quickly. To preserve and make available the sugar of this apple, it is necessary, therefore, to remove the undesirable constituents and prepare a concentrated syrup. This is done by treating the juice with slaked lime, filtering off the precipitate formed through cloth, adding a little acid and concentrating the filtrate in an open pan over a fire, to about a sixth of the original volume of the juice. Thus a thick syrup is obtained, golden yellow in colour and almost odourless. About an ounce of syrup could be prepared from five fruits at little cost.

The syrup, containing as it does only invert sugar, is easily assimilable and therefore makes an important article of food. Its greater use, however, would be in preserves and confectionery.

* * *

At the time of the tenth anniversary celebration of the Establishment of the Indian Cotton Committee and the Technological Laboratory, on 29th May, certain extensions to the field of activities envisaged by the laboratory were made.

The laboratory was originally intended for helping cotton breeders to evolve new varieties of cotton which would be an improvement over existing varieties, in point of yield, hardihood, ginning percentage, spinning quality, etc. The work of the laboratory was next extended so as to undertake the tests on samples submitted either by the East India Cotton Association or the Mill Owners Association of Bombay and Ahmedabad. A certain amount of work was also done to determine the susceptibility of cotton to certain insect pests. Researches on the properties of cotton fibre, as well as on the effect of the different processes on the quality of yarn spun from a cotton was also being carried out.

It is now proposed to extend the scope of the laboratory, so as to afford facilities for investigations on bleaching, dyeing, mercerising, and finishing operations. The laboratory will also embark on a scheme of propaganda for disseminating scientific and technical information available to the indigenous industry.

In this connection, it may be pertinent to refer to the recent statement of Mr. H. C. Shrot, who recently visited India, before the Lancashire Indian Cotton Committee, in which he mentioned that while in India he was shown several strains of cotton which compared very favourably with some of the cotton now being imported by Great Britain from foreign countries. It would take some time before these cottons could be produced in India in large quantities, but in a few years India would be able to supply England cottons, fully equal to what they were purchasing elsewhere at present.

Pulp and Paper Conference.—A conference of pulp and paper interests in India met at Calcutta on March 13th and 14th, and as a result of the discussions it was proposed to request the paper pulp section of the Forest Research Institute at Dehra Dun to investigate, (1) The mechanical treatment of bamboo prior to digestion, (2) Manufacture of mechanical pulp from bamboos, (3) Treatment of mixed species of bamboos, (4) Examination of Sabai grass (*Ischoemum angustifolium*) from different areas with regard to percentage yield of pulp and bleach consumption, and (5) Investigation of the various causes responsible for the discolouration of pulps and papers made in the mills.

According to an Editorial note published in the *Indian Forester*, the work will be taken in hand by the Forest Research Institute and carried out as quickly as staff and funds permit.

* * *

Under the auspices of the Indian Society, London, an exhibition was organised at the Alpine Club Hall; the collections of Mr. J. P. Baker, one of the world's foremost textile printers, consisting of beautiful specimens of hand painted cotton of the eighteenth century are on view. These exhibits, which have been grouped under three classes, pure Indian, Chinese influence, and Western influence, cannot fail to impress the glorious art that was India's.

* * *

A scientific expedition under the leadership of Professor Mark of Vienna University, has discovered that glacier ice on the Jungfrau (Switzerland) contains heavy water in 1 : 2,500 concentration which is double that present in normal ice. (*Chem. Age*, 1935, **32**, 405.)

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What is considered to be the world's rarest liquid, "heavy oxygen water" is now being produced at the University of Manchester by means of a recently constructed diffusion apparatus. Professor M. Polanyi and J. B. M. Herbert recently demonstrated the production of heavy oxygen water by the newly designed apparatus which is capable of yielding only 2/5 of a drop per day. One atom out of every 100 of oxygen has an atomic weight of 18, and the concentration of heavy oxygen is considered to be an achievement, since the difficulties are much greater than in separating the three kinds of hydrogen recently discovered.

* * *

Professor William C. Rose of the University of Illinois recently announced the results of his experiments on the isolation of α-amino-β-hydroxy butyric acid, an amino acid which is claimed to be absolutely essential to growth and life. This essential amino acid has also been prepared synthetically. About five years ago, Dr. Rose and his associates fed animals with a mixture of foods free from protein but containing a mixture of all the 21 amino acids then known. The animals receiving such a food declined rapidly in weight and eventually died. This was interpreted to indicate the presence, in proteins, of a hitherto unknown component which was essential to life. Further research resulted in the isolation of the new amino acid, which when added to a protein-free diet containing the 21 previously known amino acids produced normal growth.

An Electrolytic Process for extracting casein and lactose from skimmed milk, described by J. Kato (*J. Soc. Chem. Ind. Japan*, 1934, No. 4), utilises a three-compartment dialyser. The two end compartments are filled with water and contain respectively a carbon anode and a brass cathode. Adjoining the anode is a chromated gelatine-impregnated silk membrane while the membrane at the cathode is made of similarly impregnated canvas. These membranes oppose passage of lactose towards the central chamber. Strict control is kept of the acidity in the central compartment. During electrolysis (100 volts, 1 amp.), a gradual reduction in hydrogen-ion concentration is recorded as the various metallic ions (calcium, magnesium, potassium, etc.) migrate to the cathode compartment while the acidic ions pass into the anode compartment. On approaching the iso-electric point, casein begins to coagulate and is separated in a very pure form by filtration while the filtrate is a lactose solution likewise free from all but traces of mineral salts. Chemically pure lactose is isolated by evaporating in a vacuum, and centrifuging. (*Chem. Age*, 1935, **32**, 405.)

* * *

According to a note appearing in *Science* (1935, **81**, Science News, page 8) Dr. F. A. Gibbs, H. Davis and E. L. Garceau of the Harward Medical School, reported to the American Physiological Society that an electrical hook up to the brain producing wavy lines traced on paper, gives a new clue to what goes wrong in epilepsy. They find by this means that epilepsy is probably a neurological storm which results in great piling up of electrical discharges.

* * *

According to a note appearing in *Science* (1935, **81**, 340) the cause of the synchronous flashing of fireflies is really to be sought in the mating habits of these insects. Professor John Bonner Buck of the Zoological Laboratory, The Johns Hopkins University, has shown that in *Photinus pyralis*, the male flies emit single flashes about every 5.7 seconds. The female remains in the grass, and responds to some near male by flashing shortly (2.1 seconds) after each of his flashes. This exchange of signals continues until the male reaches the female. The essential factor involved is that the female who flashes only in response to the flash of the male invariably maintains the period of about 2.1 seconds at which she replies to the flash of the male. A striking feature of this "attraction" is that whereas the exchange of signals is initiated by a single pair, other males within a range of about 10 feet often join in also, so that as many as 5 flies may fly towards one female. The same response may be induced by selecting a male and in proper imitation of the female, flashing a torch light about 2.1 seconds after each of his flashes.

* * *

Marketing Officers for Travancore.—At the joint meeting of the Assembly and the Council of Travancore presided over by Sir Muhammad Habibulla, a sum of Rs. 3,440 was set apart for the appointment of marketing officers.

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Professor S. C. Dhar, D.Sc., of the Nagpur University has just returned after a brief sojourn from Europe. During his stay in Europe, he spent some time with Professor Whittaker, and

made some valuable contributions on Relativity and Autographic Functions. He also spent some time with Professor Hadamand of Paris and his dissertation on Mathiew Functions is regarded as a standard work on the subject.

* * *

The Council of the Royal Society, London, has awarded Dr. M. N. Saha, a sum of £150 for research on the theory of the Thermal Ionisation of Gases. Dr. Saha has also been awarded the Carnegie Research Scholarship for the year 1935–36 by the American Carnegie Authorities for the above purpose. Dr. Saha is leaving for America in September next. He will undertake a world tour before returning to India.

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Dr. J. J. Rudra, at present Lecturer in Electrical Technology, Indian Institute of Science, Bangalore, has been appointed to the Chair of Electrical Engineering, College of Engineering, Madras. He is leaving Bangalore very shortly to take up his new post.

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Mr. D. Ananda Rao, Principal, Agricultural College, Coimbatore, has been appointed Director of Agriculture in succession to Mr. S. V. Ramamurthi, I.C.S.

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Mr. V. Ramakrishna, I.C.S., Director of Industries, Madras, has been appointed Deputy Secretary to the Government of Madras, Labour and Industries Department. Mr. L. B. Green has been appointed Director of Industries, Madras in succession to Mr. V. Ramakrishna, I.C.S.

* * *

The Mathematics Student (Vol. II, No. 4, December 1934):—(1) Pandit Hemraj gives alternative proofs of a certain extension of Wilson's Theorem in the theory of prime numbers, originally stated and proved by Gauss. (2) T. R. Raghava Sastri proves the following theorem: If ABCD and A′B′C′D′ are two homographic tetrads of points on a conic S, the six meets of pairs of corresponding joins like AB, A′B′ together with the six meets of pairs of non-corresponding joins like AB, C′D′ lie on a conic passing through the pole with respect to S of the homographic axis of the two tetrads. Several corollaries and special cases are discussed. (3) A. Narasinga Rao discusses and interprets in terms of mechanics the proper and improper solutions of the following problem: Given any number of points, $A_1, A_2, \ldots A_n$, not necessarily coplanar and a function $f(r)$ which is single-valued, continuous, positive and monotonic increasing to infinity with r, it is required to determine the position of a point P such that

$$\phi(P) = a_1 f(r_1) + a_2 f(r_2) + \ldots\ldots + a_n f(r_n)$$

shall be a minimum, the a's being positive constants, and $r_1, r_2, \ldots\ldots$ the distances PA_1, $PA_2, \ldots\ldots$ (4) K. Rangaswami discusses some properties of ortho-lines and "orthopoints" with reference to conics passing through A, B, C and P, and conics having ABC as a self-polar triangle.

* * *

We have recently received from Messrs. Activated Sludge Limited, London, a pamphlet on the activated sludge plants in India by Dr. Gilbert J. Fowler, D.Sc., F.I.C., F.R.San.I. The pamphlet gives brief summaries of the studies made and the results obtained from the eleven installations, which have been kept under scientific supervision, at any rate, during the earlier periods of their operation; and consequently they are all virtually scientific experimental solutions by means of which the very varying conditions such as are met with in India, have received careful study. Nine of the eleven plants are in actual operation to-day; two others which have been in satisfactory operation, were closed down at the end of their experimental periods.

* * *

Deming Pumps.—We have recently received a catalogue (No. 30) of the Deming Pumps, of Messrs. The Deming Company, Salem, Ohio, U.S.A., which, we believe, will prove to be of great interest to all those interested in pumping equipments—distributor and dealer, architect and engineer, and industrial executive. The Firm which enjoys a world-wide reputation, was established fifty-four years ago, and has specialised in pumps construction, a feature which is responsible for the progressive spirit and traditional quality associated with the Deming name. The catalogue draws attention to a very wide range of equipment—centrifugal and rotary pumps and cylinders, spray pumps, etc.—which will meet every requirement.

* * *

Announcement:—

Congress of the F.E.A.T.M.—Dr. Rosedale writes:—At the next Congress of the Far Eastern Association of Tropical Medicine it is proposed to hold a round-table discussion on nutrition.

Papers are invited upon Nutrition from the widest point of view under any of the sub-headings below.

If suitable support is forthcoming, it may be possible to combine the papers received and the discussions in a volume, which would constitute an up-to-date account of Nutrition as concerns the East.

It is hoped that some indication of the support which may be expected may be received during 1935, though it will not be necessary for titles of papers to be sent in until a later date which will be notified in due course. Such co-operation will enable the Council to know how much time should be allotted for the discussion.

It has been proposed to divide papers under three headings as follows: *I. Economics*—to include such aspects as Agriculture in relation to human nutrition, *e.g.*, improvement of yield and quality of food crops; horticulture; fruit-growing; stock raising; dairy problems; institutional feeding; food surveys; storage; cooking, &c. &c. *II. Chemical and Physiological*—to include food analyses in the widest sense; vitamin, mineral, fat, protein studies, etc.; metabolism, basal metabolism, energy requirements, specific dynamic action. *III. Clinical*—Studies of diseases in relation to food and diet, the feeding of infants during the first year with special reference to development (height and weight); children's diseases in relation to food; nutritional œdema, atrypical beriberi; the course of infectious diseases under the influence of food; liver cirrhosis; anæmias; skin diseases in relation to food and vitamins; ulcers of the leg; leprosy in relation to food; constitutional diseases, diabetes, obesity, gallstones, gastric ulcer, etc.; clinical value of certain foods, etc.

It should be understood that the above provisional programme is intended to be as wide as

possible, and that additional suggestions from those able to make them will be welcomed. It is hoped that the subject of nutrition will receive emphasis from the general and normal point of view as well as from the point of view of disease.

All correspondence should be addressed to The Director of Public Health, Parapattan, 10, Batavia—C, Tara, Netherlands, Indies.

* * *

We acknowledge with thanks the receipt of the following :—

"Journal of Agricultural Research," Vol. 49, No. 12 ; Vol. 50, Nos. 1–3.

"The Journal of the Royal Society of Arts," Vol. 83, Nos. 4301–4304.

"Indian Journal of Agricultural Science," Vol. 5, Part I, February 1935.

"Contributions from Boyce Thomson Institute," Vol. 7, No. 1, Jan.–March 1935.

"The Biochemical Journal," Vol. 29, No. 4, April 1935.

"American Journal of Botany," Vol. 22, No. 4, April 1935.

"Canadian Journal of Research," Vol. 12, No. 4.

"The Chemical Age," Vol. 32, Nos. 826–829.

"Berichte der Deutsche Chemischen Gesellschaft," Vol. 68, No. 5.

"Experimental Station Record," Vol. 72, Nos. 3 and 4.

"Electrotechnics," No. 8, April 1935.

"Forschungen und Fortschritté," Vol. 11, Nos. 13 and 14.

"Indian Forest Records," Vol. 20, Part 16, (Silviculture Series).

"Transactions of the Mining and Geological Institute of India," Vol. 30, Part I, May 1935.

"Indian Meteorological Department : Scientific Notes," Vol. VI, No. 63. Wind Data for Wind Mills.

"Bulletin of the U. P. Academy of Sciences", Vol. III, 1933–34, No. 5 ; Vol. IV, Part II.

"Proceedings of the Academy of Sciences (United Provinces of Agra and Oudh, India)," Session 1934–35, Vol. IV, Part III.

"Industrial Possibilities of some Research Work done in India," by Dr. G. J. Fowler.

"Advance Proceedings and Notices of the Asiatic Society of Bengal," Vol. II, April–May 1935, No. 2.

"Nature," Vol. 137, Nos. 3417–3419.

"Natural History," May 1935.

A Report on the Prospects of Paper Manufacture in Hyderabad State, H. E. H. The Nizam's Government : Commerce and Industries Department. Bulletin No. 4 (New Series).

"Survey of India, Geodetic Report," 1934.

"The Journal of Chemical Physics," Vol. 3, No. 5.

"Journal de Chemie Physique," Vol. 32, No. 4.

"The Indian Trade Journal," Vol. 118, Nos. 1509–1511.

Catalogues.

"Deming Pumps," Cat. No. 30, from the Deming Co., Salem, Ohio.

"The Cambridge Bulletin," No. 76, May 1935.

"Mitteilungen über Neuerschienungen und Fortsetzungen," 1935. No. 3 (May). Verlag. von Gustav Fischer in Jena.

Academies.

Academy of Sciences (United Provinces of Agra and Oudh, India):

February 1935. S. M. SHAH : *On a Formula for* $\pi r(x)$. SHAH MUHAMMAD SULAIMAN : *The Mathematical Theory of a New Relativity. Chapters III, IV and V.*—The first two chapters dealt with the Law of Gravitation. In chapter III the existing theories of the Universe have been very briefly criticised, and it is shown that extraordinary assumptions are made in these and that they are also wholly inadequate. In chapter IV a natural assumption has been made that emanations from particles of matter are not confined to our present range of observation, but that corpuscles called gravitons, finer than light corpuscles, are also emitted, though they are beyond our vision. But even this assumption is not necessary. As shown in Section V, one may start simply with the known fact that light radiations, *i.e.*, swarms of light corpuscles or radions, emanate from every part of an outer shell of a luminous body. In chapter V the assumption in Special Relativity that light from one moving body to another moving body takes the same time as light from the second body to the first, no matter how different their velocities may be, as well as the definition of common time between two bodies determined by a single journey of light are not accepted. With the help of certain generalised laws, Galileo's and Newton's Mechanics, with proper corrections for moving bodies, is completely restored : and although Einstein's Theory of Relativity is not accepted, all its practical results are deduced in full. HRISHIKESHA TRIVEDI: *The Absorption Spectra of the Vapours of Sulphur Monochloride and Thionyl chloride and their Constitutions.* HAR DAYAL SRIVASTAVA : *Studies on the Family* Heterophyidæ Odhner, 1914. *Part I—On a New Distome from the Indian Fishing Eagle–*Haliæetus leucoryphus*–with Remarks on the Genera* Ascocotyle *Looss*, 1899, *and* Phagicola *Faust*, 1920.—The paper is the first record of the occurrence of a member of the family Heterophyidæ. S. K. DUTTA: *Notes on a Case of Unilateral Atrophy of Testis in the Common Wall Gecko* (Hemidactylus Flaviviridis *Ruppel*). HAR DAYAL SRIVASTAVA : *On a New Species of* Catatropis Odhner, 1905, *from an Indian Fowl*—Gallus Bankiva Murghi.—A large number of monostomes referable to *Catatropis Odhner* were obtained from the rectal cæca of the domestic fowl, which had died after a prolonged sickness. CROMWELL OSBORN DAS & SIKHIBHUSHAN DUTT: *A Study of Some Organic Reactions at Low Temperatures.* RADHA RAMAN AGARWAL AND SIKHIBHUSHAN DUTT: *Chemical Examination of the Roots of* Citrullus colocynthis *Schrader*—A hydrocarbon hentriacontane $C_{31}H_{64}$, *a*-elaterin $C_{28}H_{38}O_7$ and amorphous saponin have been isolated.

Indian Academy of Sciences :

May 1935. SECTION A.— B. V. RAGHAVENDRA RAO: *The Doppler Effect in Light Scattered by Liquids.*—The influence of temperature on the nature of Doppler Effect in light scattered by carbon tetrachloride has been studied. Whereas

at 70° C. the Doppler components become fainter and broader merging with the undisplaced component which brightens in intensity, at the temperature of melting ice, the Doppler components become sharper and move away from the central component. N. A. SHASTRI: *Some Properties of the k-Function with Non-integral Index.* S. CHOWLA: *On a certain Arithmetical Function.* P. N. KURIEN, C. J. PETER AND K. C. PANDYA: *The Condensation of Aldehydes with Malonic Acid in the Presence of Organic Bases. Part III—The Condensation of Salicylaldehyde with Ethyl Malonate*—Good yield (58%) of the condensation product was obtained when 0.15 mol. of pyridine was added to the mixture of aldehyde and ester, the whole kept on a waterbath for 18 hours (6 hours a day for 3 days) and then left at room temperature for 3 days. INDER CHOWLA: *Some Problems of Waring's Type.* R. S. KRISHNAN: *The Reciprocity Theorem in Colloid Optics.*—The conclusions derived from the dynamical Principle of Reciprocity admit of a very simple and direct experimental test which has been carried out and found to be satisfied by all kinds of colloidal solutions, emulsions, suspensions, etc., irrespective of size, shape or structure of the particles contained in them. HANSRAJ GUPTA: *Decompositions into Squares of Primes.* T. S. WHEELER: *On the Theory of Liquids, III.*—An attempt has been made to consider the vibratory motion of the molecules, and the amplitude of vibration β has been linked with the density, internal latent heat of vapourisation, surface tension, viscosity and vapour pressure. Formulæ relating viscosity with surface tension, and vapour pressure with internal latent heat have also been obtained. P. K. RAMAN: *Heat Radiation from the Clear Atmosphere at Night.* K. R. RAMANATHAN AND L. A. RAMDAS: *Derivation of Ångstrom's formula for Atmospheric Radiation.*—The processes taking place in the neighbourhood of the ground on radiation nights are complicated, and for their elucidation, the changes taking place both in the soil and at higher levels in the atmosphere have to be studied. R. K. ASUNDI: *The Band Systems and Structure of CaCl.* N. S. NAGENDRANATH: *The Dynamical Theory of the Diamond Lattice, Part II.—The Elastic Constants of Diamond.*—The expressions for the elastic constants of diamond have been found in terms of the molecular force constants and their values have been evaluated approximately. C. S. VENKATESWARAN: *The Raman Spectra of Some Metallic Halides.*—The paper describes the results of the study of the Raman Spectra of the halides of cadmium and zinc as well as of magnesium chloride, magnesium bromide and aluminium chloride.

SECTION B.—BIPIN BIHARI SINHA: *Morphology of a New Genus of Trematode, Family* Aspidogastridæ *Poche*, 1907, *from the Intestine of a Tortoise,* Lissemys punctata. R. H. RAMACHANDRA RAU: *Mechanism of Increase in Amylase Activity during Autolysis of Barley Powder.*—During the autolysis of barley powder no amilokinase is formed, observed increase in amylase activity being solely due to increased liberation of β-amylase of barley. S. S. PATWARDHAN: *On the Structure and Mechanism of the Gastric Mill in Decapoda. V. The Structure of the Gastric Mill in Natantous Macrura Caridea.*—The paper deals with the tribe Caridea of the Natantous Macrura, characterised by the absence of a gastric mill. Eighteen types of Caridea have been examined. FROILANO DE MELLO: *On a Toxoplasmid of* Fulica Atra *L. with Special Reference to a Probable Sexuality of Agametes.* B. SAHNI AND A. R. RAO: *Further Observations on* Rajmahalia paradoxa.—The revised impression regarding the peculiar plant impression from an unknown locality at the Rajmahal Hills, regards it as an inverted funnel-like organ fallen from the top of a Bennettitalean receptacle and bearing on its inner surface the impress of the seeds and interseminal scales once pressed against it, but now no longer preserved. R. GOPALA AIYAR: *Early Development and Metamorphosis of the Tropical Echinoid* Salmacis bicolor, *Agassiz.*—The full development of *Salmacis bicolor*, a tropical form has been traced both in regard to the external characters and several internal features. PRAKASH CHANDRA JOSHI: *Development of Anomalous Secondary Vascular Rings in the Root of* Spergula *L.*—The anomalous secondary growth in the Vascular cylinder of the root of the two species of *Spergula, S. rubra* and *S. pentandra*, is recorded, and the details of such development in *S. rubra* have been described. B. N. SINGH AND K. KUMAR: *Photosynthetic Behaviour of Leaves to Variations in Temperature.*—The progress of assimilation from day to day in a young radish leaf for 20 days is deduced from the separate time-assimilation curves of mature and old leaves and the effect of variation of temperature is recorded. B. N. SINGH AND K. KUMAR: *The Reactions of the Assimilatory System to Alterations of Light Intensity.*—At the normal atmospheric pressure of carbon dioxide the intensity of assimilation increases measurably with the intensity of illumination upto 68,760 metre candles in radish leaves. P. J. GREGORY: *Cytological Studies in Safflower* (Carthamus Tinctorious *Linn.*).—The cytology of this plant of economic importance has been investigated and reported for the first time. J. F. DASTUR: *Diseases of Pan* (Piper Betle) *in the Central Provinces.*—A detailed account of foot-rot, leaf-rot and anthracnose diseases which are known to occur in epidemic form is given.

Industrial Outlook.

Future of Electrical Development in India.

By T. D. Chatterji,

Department of Electrical Technology, Indian Institute of Science, Bangalore.

GENERAL OUTLINE.

THE unprecedented grid-developments from water power during the last five years in the Punjab, United Provinces and Madras Presidency has well established the adaptable possibilities in fields of Industry and rural electrification, that can be attained from the energy of the vast water resources of India. At the same time the recent decision of the Government of United Provinces to erect 1,500 tube-wells for irrigational purposes at the expenditure of 12,000 kw to 28,000 kw, the present ultimate generating capacity of its hydro-electric scheme shows clearly how the problem of irrigation must always be the predominant partner when dealing with water and its uses in India, whereas in most countries irrigation is unimportant or is on equal terms with power. Table I shows the sceptic outlook with which the water-power development in India is treated; in spite of the fact that other countries possessing such practical potentialities were fast harnessing the aforesaid source of energy with all the latest improvements in hydraulic and electric machinery.

TABLE I.

Hydro-Electric Works in India.[1]

Locality	Power installed KW or K.V.A.	Units Generated p. a. (millions)	Transmission Line—Miles	Head Feet	Province and its Probable Ordinary minimum Power in KW.
Shillong	300	0·4	?	?	Assam 621,100
Darjeeling	1000	1·6	3	275 & 650	Bengal 1000,000
Kurseong	400	..	..	?	..
Tata Power Co. ..	109,500	200	77	1640	..
Tata H. E. Power Co.	60,000	120	43	1725	..
Andhra Valley ..	60,000	160	56	1740	..
Gokak Mills Co. ..	1570	6	?	210	..
Bhatghar Dam ..	1024	1	?	46 to 100	Bombay 773,000
Kashmir	4000	2	54	390	..
Jammu	1200	1	?	26	Kashmir 458,000
Pykara	23,430	..	316 route miles	3000	..
Karteri	1000	2	3½	650	..
Munar	1100	1·7	?	380	..
Annally	110	0·1	..	800	..
Kotagiri	70	0·1	?	700	Madras 400,000
Malkhand	250	0·2	?	8	N. W. F. 1000 000
Uhl River	48,000	..	173 and others	1800	..
Amritsar	525	0·5	..	6 to 10	..
Patiala .. .	213	0·2	..	8	..
Simla	1750	6	21	540	Punjab 1190,000
Ganges H. E. Scheme ..	9000	..	1000	9–18	..
Nainital	450	0·8	..	1500	..
Hardwar	450	0·3	..	..	..
Mussorie	3750	3·5	10	1000	U. P. 605,000
Cauvery Falls	37,500	153	200	400	Mysore

Though the probable reserve of Indian Coal as estimated by T. H. la Touche reaches the stupendous figure of 79,500 million tons,[2] still her immense potentialities in water-power, both intrinsically and because of the distance to which coal has to be carried are significant enough, to cause serious thought. Moreover, recent and almost revolutionary advances in the design of hydraulic turbines of the propeller type have greatly modified the whole aspect of low-fall hydro-electric schemes, another dominant factor embodied in such enterprises in India.

[1] Mears, *Water Power*, 1934.

[2] T. H. Ronaldson, *Monographs on Mineral Reserves with Special Reference to Our British Empire*, John Murray, 1920.

Though, during the last decade the steam and Diesel Engines have played an important part in increasing the capacity of electric supply undertakings in this country, still the concentration on India's water-power resources are fully justified.

TABLE II.

Indian Power Resources.[2,3]

WATER POWER		COAL			
Probable ordinary minimum power (k-watts)	Probable maximum for development (k-watts)	Actual reserves in Tons	Output of Indian coal-fields in Tons		
			1916	1917	1918
7,532.000	12,680,000	4,45,833×1000	17,254,307	18,212,918	20,721,543

Considering the inferior nature of Indian Coal, we might take 1-hp-year as being equal to 4 tons as a fair average. On this basis the 1918 output is capable of yielding 5180385-hp-year or 3865960 kw-year, which is only about half the probable ordinary minimum available water-power out of which hardly 5% has been developed: five years back there were only Bombay and Cauvery Falls hydro-electric schemes worth the name of recording.

Till now it has been a characteristic feature of the hydro-electric power systems in India that wherever they have developed so far, the consumption *per capita* has gone up in comparison with other regions of electric power. For instance, in Bombay, which has made available the largest amount of hydro-electric energy in India, the consumption *per capita* is over 200 units.[4] In Mysore and Bangalore the Cauvery Falls Hydro-electric Scheme has made possible a consumption of about 100 units[4] *per capita*. Whereas in the cities possessing up-to-date steam power plants the consumption *per capita* is much less. Thus Calcutta, which ranks both in industrial and intellectual reputation with Bombay consumes about 110 units.[4] In Madras, which is a neighbouring city of Bangalore and the third port city of India, the consumption *per capita* is as low as 30 units[4] only. The average demand per head of population varies from 5–6 kwh in the smaller cities.

There is thus considerable market for electrical energy and if cheap power can be made available it will be readily absorbed. Of late, these expectations have been amply fulfilled by the three important provincial projects undertaken by their respective Governments, even to the extent of rendering rural electrification successful. At present owing to the encouraging demands each of these provinces have proposals on hand to develop the schemes still further.

PROPER UTILISATION OF WATER-POWER.

With some idea of the status of water-power resources in India, we can now consider the problem of rational distribution of electrical energy as far as possible over a vast area of 4·66 million square kilometers, with its far and widely located water-power resources. Also, the Indian conditions differ materially from elsewhere, owing to her dependence on well-defined "monsoons" instead of casual rainfall all the year round. As a direct consequence of this India has one type of hydro-electric development without parallel elsewhere, namely that found in the Tata chain of schemes in the Western Ghats of Bombay. For the proper utilisation with profit an immediate and new orientation in the trend of development of transmission systems in India, is needed, most probably in the direction of increased interconnections. With the following proposed Indian super-power grid systems (Fig. 1, Map of India) it is feasible to supply economically the entire energy requirements of the country with the exception of certain restricted areas where power transmission is very difficult. These six sections of Extra High Tension lines will cover a total distance of nearly 6,000 miles. The longest of these are each nearly 1,200 miles in length, while the shortest line between Tuticorin and Madras has

[3] Mears, *Hydro-Electric Survey of India.*

[4] Basu, *Proc. World Power Conference* (held at Berlin), 1930, Vol. **10**. (D. Ing. J. N. Basu of Bengal Technological Institute of Jadabpur, Bengal).

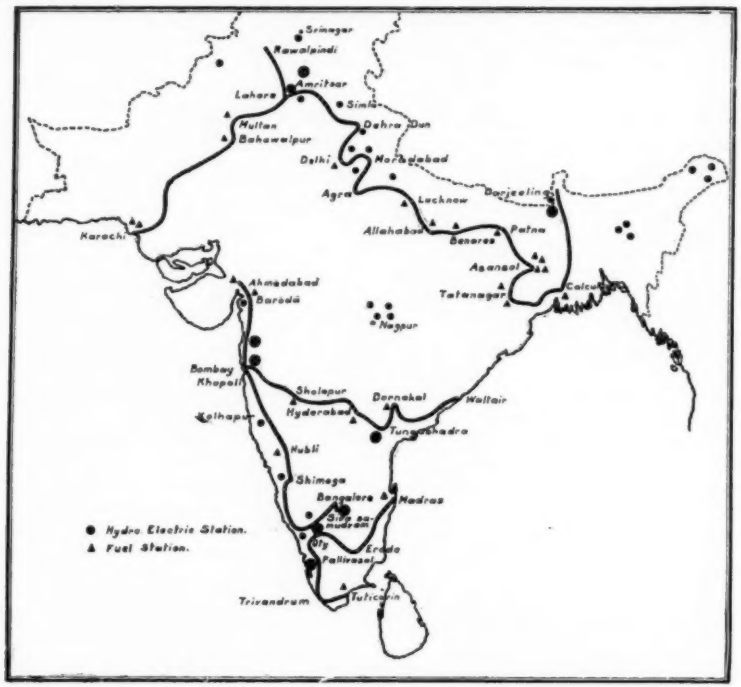

Fig. 1.

a length of 700 miles. In view of these unusual distances and vast interchange of power over such a system the minimum transmission pressure tends to increase somewhere about 400 kv. In order to secure stability in a project of such a nature, it is of vital importance to augment the power by the energy generated at the would-be super-power stations situated on the coal fields, say, for example, in Bihar Province.

As the extent and development of water-power in a country varies in accordance with topographical and climatic changes and is also affected by variations of policy in different administrations, so the first natural sequence will be the immediate formation of a Central Electricity Board of an all-India nature. It must be represented by Engineers, Industrialists and Chemists in order to prepare regular and systematic power survey reports and to investigate thoroughly the nature and extent to which the cheap electric power, thus made available, can help to create new industries. Amongst these may be mentioned (*a*) The electric smelting of indigenous iron ores and electric production of steel and alloys, (*b*) Electric welding, (*c*) The production of aluminium from the local bauxite deposits, (*d*) The manufacture of calcium carbide and its numerous derivatives, (*e*) The electrolytic production of chlorine gas and the preparation of phosphorus and of abrasives like carborundum, (*f*) Pulp and paper industry with printing, (*g*) Manufacture of electro-chemical products such as synthetic fertilisers for which there is a great demand in India, (*h*) Economical irrigation of a vast area of uncommanded land by tube-well pumping or by gravity lifts from existing canals, (*i*) Reclamation by draining water-logged lands. In addition to these attempts can be made to increase the domestic load and accelerate the electrification of Indian Railways in suburbs.

Considered from the expenditure side, the adequateness of such a scheme with a well-defined objective and policy can undoubtedly be established in its favour. For example, taking Madras Presidency, which imports coal and fuel oil (excluding petrol) worth more than Rs. 300 lakhs, a transmission network interconnecting the projects of Pykara, Perriar and Papanasam

can be provided in order to distribute 120,000 kw all over the province at an estimated total capital expenditure of Rs. 950 lakhs, provided the total fixed charges on the capital outlay of Rs. 950 lakhs does not come up to over Rs. 70 lakhs. It would be reasonable to expect that the decrease in the value of the imported fuel, on account of motive power supplanting raw fuel engines, will be in excess of these charges.[4]

In India there are several provinces (say Assam) where the demand is far less than the available supply owing to the distances of the sources from the industrial centres. The energy in such localities might be utilised with the help of chemical endothermic processes, for the production of compact materials for transportation to the industrial centres where by exothermic processes they might generate heat and power.

In India unlike in other countries it is possible to build up a load only in those places which are to be served by these super-grids after their completion. In fact the author estimates that these projects after the completion on the suggested line will be able to supply power at any point in the grid at an average price of 1 anna,* about Rs. 200 per kw-year whereas from the bulk of the smaller oil-driven plants throughout the country the rate is about 2 annas per kwh (unit). River Teesta in Bengal with a hydro-electric power generating capacity of 1,000,000 kw and River Koyna in Bombay with 250,000 H.P. need immediate attention for harnessing purposes.

THE TREND OF TRANSMISSION PRACTICE.

With an eye to the proposal, let us examine the noteworthy advances in transmission practice which go to materialise a scheme of this character. Within the last ten years a number of 220 kv lines have been put into successful operation in different countries and this voltage has now become the standard transmission voltage for very long distances. Further to keep down the weight of copper and hence the cost of the line it was proposed at the World Power Conference in 1930 to examine the practicability of 400 kv for the operation of an European Super-power Grid of nearly 7,000 miles; and with such values of transmission distance and transmission voltage the difficulties mentioned below are introduced.

Transmission line requires excitation or charging current which varies with the load, and its supply has to be regulated by means of Synchronous Condensers. This charging current being wattless contributes towards the transmission losses, which depends upon the capacitive reactance of the line which is again proportional to the length of the line and to the frequency of the alternating current; hence it is at once seen that by reducing the frequency the power-transmitting or kilo-watt capacity of the line can be raised. By using direct current we drop the frequency to zero and it is thus that the inevitable conclusion is reached that it is the only means of increasing the transmission distance. Inductance and Capacitance vanish. The transmission line becomes stable under all possible conditions of loading and intermediate stations for compensating reactive drops become unnecessary. Apart from these advantages,

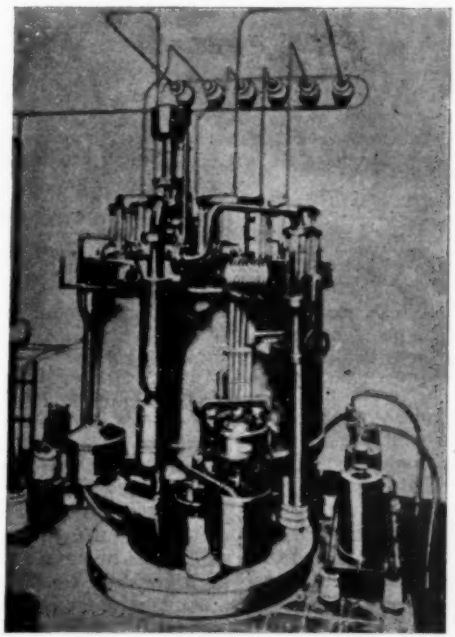

Fig. 2.

Steel tank rectifier 750 kw capacity at 15,000 volts.

the skin effect, characteristic of alternating current at high voltages is absent in the case of direct current. Corona loss with direct

[4] Basu, *Proc. Second World Power Conference*, 1930.

* 1 Rupee = 1¼*sh.* = 16 annas.

Fig. 3.

current is considerably less and for the same degree of insulation to earth the operating voltages for d.c. and 3 phase a.c. transmission are in the ratio of 65 to 23.

Even though the d.c. transmission is to form the future basis of long distance transmission, it is still essential to generate first alternating current in large high-speed machines and then to convert it to d.c. in relatively few units of efficient apparatus of static nature. It is, furthermore, equally essential that similar apparatus be employed for transforming the high tension d.c. back again to 3 phase a.c. at constant voltage for subsequent distribution throughout the existing power networks. Such apparatuses have already been manufactured on a smaller scale and are known as Rectifiers and Convertors (Fig. 2). Experimental transmission in the laboratory at 15,000 volts has very recently been achieved by the General Electrical Company of Schenectady in America for 3000 kw lines. They employed static type of Rectifiers and Convertors commercially known as Thyratron and Phanotron respectively. The efficiency of conversion with larger units under investigation are expected to be as high as 98 to 99 per cent. Thus the present double circuit line of 132 kv of the Punjab can, without further alteration, be utilised as a triple circuit direct current line operating at 370 kv between positive and negative conductors, whilst with the assumption of similar line losses in both the cases the power which can be transmitted is nearly seven times.

Besides, through the success and organised co-operation of long distance d.c. transmission we can go still a step further by interconnecting the hydro-electric and other electric systems internationally for the reduction of power cost with a more

satisfactory equalisation of load. Another method through which the equalisation of power can be attained will be to utilise the rotation of the earth. The idea behind the proposal is to get power plants which are situated at different meridian distances in an east-westerly direction to co-operate systematically. An extreme case of such co-operation would be between a power plant which is situated on the extreme east of Asia and a similar one on the extreme west of Europe (Fig. 3). These power plants should work with a day and night displacement of 12 hours, in spite of the fact that according to absolute time calculations no time displacement exists. In this way night power in the extreme west of Europe could be transferred to day power in the extreme east of Asia and *vice versa*. At present it is rather difficult to visualise so great a relative time displacement between the maximum load of similar power plants. But even with a time shift of 3 or 4 hours much can be gained, specially in electrical tramways and suburban railway services.

The exploitation of water-power resources is essential for the needs of India. However great the distances to be covered, there are no inherent difficulties from the engineering point of view that could not be surmounted. Industry and agriculture are both in need of a "grid scheme". Sooner or later the provision of a "grid" supply is inevitable, and the Government should look ahead and find the necessary capital for the scheme.

Reviews.

NEW PATHWAYS IN SCIENCE (Based on the Messenger Lectures of 1934). By Sir Arthur Eddington. (Cambridge University Press, 1935). Pp. x+333. Price 10*s*. 6*d*. net.

Six years have elapsed since Sir Arthur Eddington's "*The Nature of the Physical World*" was published. These years have not witnessed any revolution in theoretical Physics such as that represented by the birth of quantum mechanics. The time, however, has been utilized to take stock of the implications of the new theory and much that was obscure and changing has cleared and crystallized. Sir Arthur has seized the opportunity afforded by the Messenger Lectures delivered by him in 1934 to write a sequel to '*The Nature of the Physical World*' which bears the impress of this process of taking stock. On the other hand, recent years have produced astounding discoveries in the realm of experimental physics: we have had the neutron, the positron, heavy hydrogen and induced radio-activity coming in rapid succession before our astonished gaze. These discoveries have had their repercussion on the problems of Astrophysics so near and dear to Sir Arthur. We accordingly find in the present book a portion dedicated to the consideration of the internal constitution of stars and of the expanding Universe; another part describes the philosophical outlook of modern science as Sir Arthur interprets it. The connection between the Universe of the Relativity theory and the atom of the Quantum theory which is the theme of Sir Arthur's theory of the fine structure constant is dealt with in another chapter. Incidentally we find a treatment of Probability and the Theory of Groups included. An introductory chapter will enable any one not conversant with the modern development of Physics to get a rapid acquaintance with the most recent discoveries. The subject is throughout treated in the charming pictorial style which we have come to associate with Sir Arthur. In spite of the difficult nature of some of the topics dealt with, even a layman will have a chance of understanding the direction in which modern Physics is advancing as viewed by Sir Arthur. The Indeterminacy Principle, Eddington's recondite theory of the fine structure constant, and the theory of Groups are all explained in such a lucid manner that we feel we have understood something of even these difficult matters. Sir Arthur thus provides an example of how even higher mathematics may be made intelligible to laymen.

This success in providing a popular exposition of such difficult subjects has, however, one drawback: the language is imaginative and picturesque, but the metaphorical statement sacrifices something of precision and the reader is likely to mistake a vague idea which he sometimes obtains for a profound understanding of the subject. Thus Pauli's principle that no two electrons

can have the same n, l, (s), m_l and m_s values has been presented in the form "No two electrons may occupy the same orbit." Since m_s is not connected with the orbit of the electron, we see how even a careful popular statement may lack accuracy. The same trouble arises in connection with the presentation of the philosophy of modern science: the figurative language very often confuses the thought. Sir Arthur has tried to answer such criticisms by protesting that a popular account should not be made dry-as-dust by hankering after precision. We do agree, but include a warning to the reader that he must also keep this in mind. We imagine that Sir Arthur's philosophy has been criticised by philosophers mainly as the result of misunderstanding the working convictions of a scientist for a profound philosophical system. Science does not attempt a philosophical system which can hold true for all its parts without any discrepancies. A view reached after studying a topic from a particular standpoint may not *exactly* represent the idea one gets by pursuing another subject by a method appropriate to the latter. If it has been shown that according to present theoretical possibilities of refinement in measurement in Physics, a certain amount of uncertainty necessarily attaches to the simultaneous values of two conjugate quantities, we can only say that Physics has for the present to be satisfied with a theory which tolerates and takes into account this uncertainty. But we cannot lay it down as a philosophical dogma that indeterminacy is at the bottom of modern scientific method. If we express the law of causality in the form that the same set of circumstances always produce the same phenomena, we see that the principle is the basis of all science. We may doubt our ability to produce the same circumstances or to be sure of their sameness when they are produced. Thus in radio-activity we cannot say which of two apparently similar atoms will explode next because we have no detailed knowledge of the real difference between them. But if we doubt whether the same results will always follow when *all* the conditions are theoretically supposed to be fulfilled, science and particularly experimental science would be at an end. This is the aspect which Planck and Einstein have stressed and Silberstein has elucidated in his book on causality. Whenever circumstances which are apparently the same produce different results, we try to find out what other circumstance we have omitted to take into consideration and which was responsible for the difference in the results. Modern physical theory may not be able to rise above the uncertainty involved in the methods of measurement it can contemplate. It is therefore profitable to recognize this uncertainty, but it would seem as if a belief in the principle of causality was the driving force at the back of the never-ending striving after new knowledge. Since as Sir Arthur pertinently points out, science is not wedded to one self-consistent and immutable philosophical system, we may possibly add that it is fruitless to consider either the principle of causality or that of uncertainty as a philosophical dogma. Let us however employ the one as a working principle without being blind to the existence of the other in modern Physical theory. Sir Arthur has tried to show that adherence to the principle of causality is not demanded by modern Physics; but it may not be opportune to give up a principle which has been the basis of all scientific development, particularly since there is nothing in Physics which demands its sacrifice. A perusal of Sir Arthur's replies to his philosopher critics shows that he has taken his stand as a man of science to whom philosophical consistency is not the main consideration. If this point is grasped there is no necessity for any criticism regarding his having stated his convictions not always in the same terms. We do not profess to have penetrated the mystery underlying his theory of the fine structure constant, but recent discussions of the accuracy of grating measurements of X-ray wave-lengths show that the experimental value of that constant is quite near the figure demanded by his theory and even the small discrepancy which remained appears now to vanish. Under these circumstances, we welcome the lucid exposition of the idea behind the formidable mathematics of his theory. And though one may not see eye-to-eye with the author in all that he says, one must welcome the appearance of such an able account of present-day problems and must recognize the not very common success with which abstruse subjects have been made intelligible to the common understanding.

T. S. S.

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GRAINS DE MATIÉRE ET DE LUMIÉRE: PREMIÉRE PARTIE: EXISTENCE DES GRAINS

(12 fr.); DEUXIÉME PARTIE: STRUCTURE DES ATOMES (14 fr.); TROISIÉME PARTIE: NOYAUX DES ATOMES (7 fr.); QUATRIÉME PARTIE: TRANSMUTATIONS PROVOQUÉES (12 fr.). By Jean Perrin. (ACTUALITÉS SCIENTIFIQUES ET INDUSTRIELLES, Nos. 190, 191, 192 and 193. Hermann et Cie, Paris, 1935.)

All who have been charmed by the vivacious style and the beautifully clear exposition of Perrin's "Atoms" will welcome these monographs by the same master hand. There is the same verve and elegant presentation undiminished by the passage of years. It is interesting to learn incidentally from these books the part played by Perrin in the modern development of Physics. The first two parts contain an account of the structure of atoms and molecules presented in a fresh and logical manner without any mathematical details but including the results of mathematical arguments. The third gives an account of radioactivity while the fourth discusses the modern discoveries of the neutron, positron, heavy hydrogen and artificial radioactivity and the implication of these in the structure of nuclei. The treatment throughout the four monographs is from a modern viewpoint, the old problems being organically connected with the latest results. Towards the close are some interesting speculations about the structure of neutrons, protons and nuclei and the origin of cosmic rays. There is unfortunately a larger number of misprints than we should like to see. There are also one or two mis-statements such as the one which ascribes Compton's discovery to the year 1925 or which says that the atomic number of Pt is 77. These are, however, very minor matters. The fresh and unified presentation of the old and the new can elicit nothing but admiration; the range of topics includes the latest developments which cannot yet be found in any text-book. The books will no doubt thrill all readers into enthusiasm for the subject they treat and we heartily recommend them to scientific workers and lay readers alike.

T. S. S.

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AU DELA DE L'ÉLECTRON. By Sir J. J. Thomson, O.M., F.R.S. Translated by R. Fric. (ACTUALITÉS SCIENTIFIQUES ET INDUSTRIELLES, No. 211. Hermann et Cie, Paris, 1935.) Price 7 fr.

This is a translation of Sir J. J. Thomson's "Beyond the Electron" with a preface by M. A. Cotton. It is befitting that the discoverer of the electron should also try to give us a picture of its constitution. Until recently the electron played a rôle only as a point charge but modern developments have made it necessary to probe into its structure. Though giving only a partial explanation, Sir J. J. Thomson's attempt to deduce the properties of the electron from a hypothetical structure is very interesting. The wave-like and particle-like natures of the electron are made to appear as necessary concomitants of its structure: the electron is supposed to have a double structure, one part consisting of lines of force where the energy is localised, and the other a train of waves in resonance with this and determining its trajectory. In this respect the electron appears to be somewhat similar to the wave-packet assumed by Sir J. J. Thomson in his theory of light. The mechanical and magnetic moments of the electron, however, do not follow from the theory, while the success of Dirac's theory was due to its explanation of just these properties. Now that Born and Infeld's theory of the electron as a singularity in the field appears so successful, it is very profitable to see how much a less formal and more intuitional conception can explain. As a contribution to this end, Sir J. J. Thomson's monograph deserves careful perusal and the present French translation will no doubt serve to draw more attention to this interesting attempt of Sir J. J. Thomson to extend classical ideas so as to furnish an answer to some of the questions which have so far found only a quantum-mechanical treatment.

T. S. S.

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PRACTICAL SOLUTION OF TORSIONAL VIBRATION PROBLEMS. By W. Ker Wilson. (Messrs. Chapman & Hall, London, 1935.) Pp. 438. Price 25*s*.

The practical experience gained by the author for several years in carrying out investigations on torsional vibration in different types of installations has been set forth in this book in a manner suitable for everyday reference. Those that are engaged in the design of high-speed engines, turbines, turbo-generators, internal combustion engines, marine installations, etc., will find the book extremely useful as the author has tackled every conceivable problem connected with their torsional vibrations. Every case discussed theoretically has been illustrated with an actual numerical example from practice and this feature adds to the value of the book a good deal.

Starting with the fundamental definitions, the natural frequency of torsional vibrations, position of nodes, and relative amplitudes for one, two, three, and multi-mass systems are calculated in the first chapter. The method of tabulating these results, taking as examples four typical engine aggregates, *viz.*, two types of direct-coupled generator and two types of marine installation, and the interesting deductions from these results, occupy a major portion of the second chapter and they are of immense value to the designing engineer and the draftsman. Practical method of tuning the oscillating system of a direct-coupled generator and the shaft system of a marine installation to produce a favourable disposition of critical speeds, are also given in the same chapter.

The oscillating systems of actual installations are, however, much more complex than the ideal systems usually discussed in books, and with a view to assist the designer in his attempt to reduce any system to the standard one, a fairly big chapter has been devoted to the calculation of equivalent masses, equivalent elasticities and equivalent systems. The determination of stresses due to torsional vibration at non-resonant speeds, phase and vector diagrams for multi-cylinder engines, stress diagrams and calculation of dynamic magnifiers are spread over two chapters and typical examples taken from Electrical Engineering and Marine Engineering practice, have been worked out.

Accurate measurements of torsional vibration amplitudes under service conditions have to be made to enable theoretical calculations to be checked and reliable damping factors to be established. The author has therefore given a full description and the method of using (1) the Geiger Torsiograph, (2) the D. V. L. (Deutschen Versuchsaustalt fur Luft fahrt) Torsiograph, (3) Rotational Decelerometer, and (4) Electro-Photographic Vibration Recorder. Torsiograph records for various engines have been given and the actual values obtained from these curves have been compared with the figures obtained from theory and any difference is accounted for.

In certain cases the natural frequency can be modified so as to secure a safe working speed range and for this four important methods are thoroughly discussed in a chapter. The amplitude of torsional vibration can be reduced by altering the position of the critical speed (1) by altering the torsional rigidity of the shafting, (2) by modifying the dimensions and distribution of the attached masses, (3) by elastically connecting a supplementary mass to the main system at a point remote from the nodes, so that the natural frequency of the added system is equal to that of the original system, and (4) by addition of supplementary mass at a point remote from the node and connecting it to the main system so that there is a periodic variation of natural frequency or an automatic change of natural frequency at critical speeds.

Alternatively, frictional damping devices, or alteration of firing order, can be used.

The last chapter deals with the dynamic characteristics of electrical generating sets direct-coupled to internal combustion engines. Among other things, the procedure indicated for obtaining the flywheel effect necessary for the satisfactory operation of parallel running alternators driven by internal combustion engines, is particularly interesting.

On the whole, the book is as eminently practical as it is theoretical and a very useful addition to any Engineering Library.

In future editions, the explanation of all the notations might with advantage be given at the beginning of the book, instead of repeating them in each chapter, and also the numbering of all the equations in the book may be made continuous instead of according to chapter.

E. K. RAMASWAMI.

* * *

THE PRINCIPLES OF ELECTRIC POWER TRANSMISSION BY ALTERNATING CURRENTS. (Third Edition.) By H. Waddicor, A.M.I.E.E. (Chapman & Hall, Ltd., 1935.) Pp. 449. Price 21*s.* net.

This publication is a revised and enlarged edition of the standard book on Power Transmission familiar to Engineers and Engineering students and is very useful for any Technical Laboratory.

The author has collected valuable information from a large volume of literature published from time to time including several standard publications of manufacturing firms of repute and given a systematic exposition of the principles of design of transmission lines and a comprehensive list of valuable references for the investigator and teacher.

The economic and fundamental electrical principles are treated in separate chapters and the calculations concerned are carefully worked out. The performances of short and long transmission lines are treated

separately with graphical and diagrammatic illustrations of the standard type. The various points of design and manufacture of conductors, supporting structures and insulating materials for overhead lines are treated in separate chapters, with full discussion of the various standard designs and their adoptability under different conditions. Voltage control by phase modifiers and prevention of dangerous currents are ably dealt with giving details and wiring diagrams of apparatus employed.

The chapter on underground cables deals in great detail with all the aspects of power transmission through underground cables and the latest developments in the design and manufacture of High Tension cables have been thoroughly discussed with very neat illustrations.

Pressure rises and protection against abnormal pressure rises is very well written and the practical Engineer as well as the teacher will find the book very interesting and useful.

R. P.

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EXPERIMENTAL PHYSICAL CHEMISTRY (Second Edition). By Farrington Daniels, J. Howard-Mathews and John Warren Williams. (McGraw-Hill Book Company, Inc., New York and London, 1934.) Pp. xix+499, 140 Figs. Price 21*s.* net.

In this new edition, the general arrangement of the first impression has been retained. Part I which provides a laboratory manual stands greatly altered in that sixteen of the less satisfactory experiments have been omitted and nine new ones have been added. Amongst the additions are experiments on: molecular films on liquids, electrokinetic phenomena, distribution of particle size in an emulsion, the dilatometer in the study of reaction rates, galvanic cells with and without transference, the glass electrode, the heterodyne beat method for dielectric capacity and heavy hydrogen. In several of the exercises retained the experimental technique has been modified with a view to secure higher accuracy. Part II (which deals with apparatus found most suitable for advanced work or research on topics dealt with in Part I) has been slightly amplified with a view to keep pace with recent literature by addition of topics such as Heyrovsky's polarograph, Raman spectrum, vapour density balance, high vacuum technique, etc. The chapters on photochemistry and capacity have been considerably amplified. Part III dealing with miscellaneous operations has been extended to include chapters on vacuum tubes and errors of measurement. One who goes through the book is greatly impressed by the number and variety of exercises and the adequate theoretical background for each of them. In view of the profuseness of the material it is to be regretted that no reference is made to the following: McBain's quartz spring balance (useful in studying solid-vapour equilibria), the determination of the thermal conductivity of gases and the construction of precision air thermostats. The importance of corrections (as determined by Harkins and co-workers) in the "ring" and the "drop weight" methods of determining surface tension could have been pointed out with advantage. In spite of these minor omissions the book would be highly useful to students as well as teachers.

K. S. GURURAJA DOSS.

* * *

THE GEOLOGY AND MINERAL RESOURCES OF BURMA. By Dr. H. L. Chhibber, PH.D., D.SC., F.G.S., F.R.G.S. (Macmillan & Co., Ltd.) Vol. 1, Geology of Burma, pp. xxviii+530. Price 30*s.* net. Vol. 2, Mineral Resources, pp. xv+309. Price 18*s.* net.

The two volumes before us constitute a substantial contribution to our knowledge of the geology and mineral resources of Burma, a country which is so aptly described as "still a land of the future." Almost immediately after he entered on the teaching staff of the newly formed Department of Geology in the University of Rangoon under the direction of Dr. L. Dudley Stamp in the year 1924, Dr. Chhibber realised the need for a decent and comprehensive manual on the Geology of Burma, and soon resolved to supply this want himself. During the next few years he deliberately set out to qualify himself by travel, field work, and laboratory study for the efficient execution of this task; and the books now under review are the result of these labours. As Dr. L. Dudley Stamp says in his appreciative Foreword, these two volumes by Dr. Chhibber "represent a valuable combination of personal research and field work and a minute and critical examination of existing literature" on the geology and mineral resources of Burma.

Vol. 1 deals with the geology of Burma and is made up of 34 chapters covering about 500 pages in all. A few of these chapters have been written in collaboration with Mr. R. Ramamirtham of the Geology

Department, University College, Rangoon. The first 9 chapters deal with such aspects of general geology as River systems, Lakes, Earthquakes, Mud volcanoes, Denudation, etc. The next 17 chapters are devoted to the stratigraphy of Burma and contain a detailed and connected account of the constitution, classification, and characteristic fossils of the different rock formations in their stratigraphical order. The palæontological portions of these chapters have been read through and revised by such eminent palæontologists as Prof. A. Morley Davies and Dr. F. R. Cowper Reed. The remaining 8 chapters deal with an intensive study of igneous activity in Burma under such aspects as its relation to tectonics, variation in time and space, variation diagrams, etc. and in writing these the author has had the valuable criticism and guidance of such well-known petrologists like Prof. P. G. H. Boswell, Prof. A. Brammal and Dr. G. W. Tyrrell. The book concludes with two valuable appendices on the correlation of the geology of Burma with that of Malaya and Assam, the former by Mr. J. B. Scrivenor, late Director of the Geological Survey Department, Federated Malay States, and the latter by Mr. P. Evans, Geologist of the Burma Oil Co., Assam.

The second volume on the mineral resources of Burma is much smaller than the first and has about 300 pages, divided into 16 chapters dealing with the various kinds of deposits of economic value found in Burma—ranging from gem stones like ruby and sapphire to soils, road-stones, and building materials. Under each type of mineral deposit, an account of its geological and geographical distribution, and present methods of exploitation have been given, together with chemical analyses, statistics of production, etc. In a few cases valuable suggestions have also been made regarding the future development of some of these mineral deposits. In writing some of these chapters, the author has wisely taken the assistance of several competent men, and thus has secured a certain amount of authority for his work. For instance, the chapter on Petroleum is wholly written by Dr. L. Dudley Stamp; many of the statements made in the chapter on Salt have had the approval of Mr. E. G. Robertson, Chief Collector of Salt Revenue, Burma; and the chapter on Soils has been written in collaboration with Mr. S. P. Aiyar of the Burma Agricultural Service. It is well known that from the point of view of mineral resources, Burma is undoubtedly the most important province of the Indian Empire; and we have no doubt that the present volume by Dr. Chhibber will be of great assistance to all those who are interested in the development of these mineral resources.

In both the volumes under review, at the end of each chapter numerous references to original papers have been given; and a perusal of the complete list of such references is enough to impress us with the extent and volume of library work which the author must have done in writing these volumes. With the subject-matter so nicely arranged and classified, and aided by the numerous and excellent illustrations so well reproduced, we have no doubt that Dr. Chhibber's volumes will long remain as valuable books of reference for those interested in any aspect of the geology of Burma.

On reading through the two volumes, we are, however, inclined to make a few observations by way of comment. In Vol. I we think that a good bit of the information of the kind given in the first 9 chapters, though interesting, is hardly necessary in a book of this kind, and might well have been cut out, thus reducing the entire matter to about half its present size, without in any way sacrificing the value of these chapters as an introduction to the study of the geology of Burma. It is also difficult to appreciate the propriety of such an intensive treatment of the igneous rocks of Burma as is embodied in chapters XXVIII to XXXIII. While we have no doubt that the information given in these chapters is of the most valuable kind, we still feel that such a detailed study dealing with igneous petrography and petrogenesis—though it be all relating to the rock types from Burma—has hardly a place in a book like this devoted to a general study of the geology of Burma. If however it is considered desirable or necessary by the author, to include these chapters for the sake of completeness, we might well ask why the same treatment should not also have been extended to the sedimentary and metamorphic rocks? With these concluding chapters in Vol. I very much abridged, and with a certain amount of general trimming in Vol. II in places where the present methods of mining etc., have been described in much too great a detail, we think it should have been possible for the author to achieve his original intention to cover in *one* volume both the geology and the mineral resources

of Burma; and this, we feel, would have been better.

In both the volumes again, we regret to see certain features in expression which are usually considered undesirable. For instance, in Vol. I, almost within a page or two, we see one and the same person variously referred to as "Stamp", "Dr. Stamp", "L. D. Stamp", "Dr. L. D. Stamp", and "Dr. L. Dudley Stamp". A locality is spelt "Nwetaung" in one place and "Ngwetaung" in another. In mentioning the fossils of the different strata, there is no consistency in the classification adopted. In one place (p. 150) Mollusca is considered as a unit of the same status as Hydrozoa or Anthozoa; while in another (p. 142) the name Mollusca does not appear but the three different classes of this phylum—Pelecypoda, Gastropoda, and Cephalopoda have been mentioned individually and each given the same status as the term Mollusca on page 150. On page 173 one cannot see why the phylum Arthropoda should come in between Pelecypoda and Cephalopoda; and on page 226 the term "Pelecypoda" which has been used so far is suddenly dropped and we get the term, "Lamellibranchiata" instead. Similarly in mentioning the different species of a genus, no consistent procedure is adopted. In one place it is *Rafinesquina imbrex* and *subdeltoidea*; in another place it is *Orthis irravadica*, *Orthis chaungzonensis*, *Orthis subcrateroides*; and in a third place it is *Productus cora*, *P. cylindricus*, *P. gratiosus*.

There are also quite a large number of passages in both the volumes where it is difficult to understand exactly what the author means, where the construction of the sentences is rather loose and not altogether happy, or where the idea expressed is much too common place to be seriously mentioned. A few such examples from Vol. I are given below: "Some of them (lakes) are important because amongst the sediments with which they have become filled in are minerals of value, including oil shales and lignite. In the southern parts of the Shan States, one of the lakes formed in this way still remains; this is the Inle lake." (p. 40); *Aristocystis* "is one of the peculiar fossils of the Ordovician period." (p. 138); "Besides *Camarocrinus asiaticus*, *Lingula quadrata*, *Orthis irravadica*, and *Plectambonites repanda* have been found in them." (p. 145); "But fortunately for Burma, there is within easy reach a whole series of richly fossiliferous Silurian deposits of this period with their rich faunas." (p. 149); "Out of 26 species found in the Irrawadian series, six are entirely of aquatic habit and two are semi-aquatic. Seven to nine lived chiefly in marshy swamps, while the remaining eight are identical with Indian Siwalik forms. Out of the 26 species, 11 at least are identical with the India Siwalik forms." (p. 254); "The origin of fossil wood is due to colloidal material associated with waters laying down the deposits in which it is preserved." (p. 256); "It was not until late Cretaceous or early Eocene times that the subterranean fires once more awoke to vigorous action". (p. 291): "In each case there is little remaining evidence to show the action of the igneous rock upon the soft sands and clays through which it passed, due partly to the rapid rate at which these beds are denuded, but at the same time, had these intrusives been accompanied by heat then the beds in contact would have shown some indications of metamorphism." (p. 393); "In the absence of fossils it is very difficult to announce the age of a formation." (p. 470).

In Vol. II we have: "When these mines are active Shan women wash for gold as they do at present in the jade mine area, while their male relatives work for rubies and other gem stones." (p. 14); "In places it (gabbro) is so fine grained and granulitic that, without the aid of a microscope, it is difficult to distinguish externally from basalt." (p. 38); "Quartz is visible in thin sections but is very subordinate, and the rock appears to be a quartz diorite. The felspar is very largely altered, but however plagioclase is predominant." (p. 40); "A stray labourer might search for jadeite boulders from the bed of the stream. This is a laborious task as the man has not uncommonly to stand in water, about thigh deep all the time while, as a rule, the reward of his exertions does not arrive very promptly." (p. 65); "The average double prismatic cleavage angle is 87·3, while it varies from 85·2 to 89·0, depending upon the angle at which the crystal is lying in the section." (p. 67); "It is noteworthy that in sales and valuations, prices are not mentioned openly, but are indicated by a conventional system of finger pressures under cover of a handkerchief." (p. 78); "A considerable quantity of stone is smuggled across the border in addition to the small amount officially carried over by mules, which return from Burma to Yunnan and China with the advent of the rainy season." (p. 79); "The cutting

(of jadeite) is done with steel wire ; generally two of three wires are plied together. The boulder rests on a wooden frame and the saw is worked by two men sitting at either end. On one side there is a small basin containing coarse carborundum powder and water, and during cutting this moist paste is continuously poured on to the boulder by means of a long rod either by one of the workmen or by a small apprentice boy." (p. 81); "The country has undergone secular changes of depression, evidenced in the coast line and interior, followed by upheaval." (p. 177); "It (Mica) is associated in a medium grained pegmatite with a micrographic intergrowth of quartz and felspar. The author had a small pit dug to a depth of about 6 feet and found that mica continued to that depth." (p. 239); "With the invention of the internal combustion engine, it is becoming essential for the development of a rice country like Burma to possess a good system of roads, linking her main river systems with the railway terminii and sea ports." (p. 87).

In pointing out some of these irregularities in expression and in quoting at some length these examples of what appear to us as unhappy in diction, let not our intention be misunderstood. We have nothing but praise and admiration for the great trouble which Dr. Chhibber has taken in compiling these two valuable volumes; we are however anxious at the same time that in a great work of this kind produced by one of us, there should be nothing which will tend to let it down in the estimation of the scientific public in India or abroad.

L. RAMA RAO.

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MANUAL ON THE AIR-SEASONING OF INDIAN TIMBERS. By S. N. Kapur, B.Sc., Ph.D. A.I.C., A.M.I.Chem.E., Officer-in-charge, Seasoning Section, Forest Research Institute, Dehra Dun. (Delhi, Manager of Publications, 1934.)

The seasoning of timber is a very important subject, which has suffered from undeserved neglect in India, considering her vast timber resources and the necessity for properly conserving them. In Europe and America, the old-fashioned method of air-seasoning has been superseded to a very large extent by the modern processes of kiln-drying. In India, however, for some reason or other, air-seasoning is the only method practised to any large extent. Even this method is not followed in an organized, scientific manner and haphazard methods of seasoning are responsible for the loss of large quantities of valuable timber. Mr. Kapur's book is therefore a very timely and useful publication.

The first part of the book is devoted to a general description of the principles and methods of seasoning timber. Among the important topics dealt with are:—Methods of Determining Moisture in Wood, Shrinkage and Moisture Relation of Wood, Mechanism of Wood-Seasoning, Seasoning Defects and their Causes, Water-Seasoning, Requirements of Air-Seasoning and Practical Methods of Stacking Timber for Seasoning. Each of the topics is briefly but very clearly dealt with and illustrated by numerous excellent plates.

The second part of the book is entirely devoted to an account of the air-seasoning characteristics of 120 of the commonest species of Indian timber. Directions about the proper methods of seasoning are given for each species. As these are mostly based on experiments by the author and his colleagues at the Forest Research Institute, they will be found very useful by all who are interested in the subject.

The printing and get-up of the book, and the illustrations are excellent. The author deserves to be congratulated for writing a very useful and instructive book on this important subject.

C. V.

Errata.

Vol. III, No. 8, February 1935.

Page	*Column*	*Line*	*Read*	*For*
341	1	56	Mergui	Murgyi
343	2	9	Adam's	Alam's
344	2	7	Uru	Uri
345	1	47	Trauth	Trouth
345	2	12	Na HKyam	Nam Hkyam
345	2	13	*Xenaspis*	*Xenorpis*
345	2	19	A new genus of the *Hungaritidæ*	The new genus *Hungoritide*

951-35.—Printed at The Bangalore Press, Bangalore City, by T. Subramania Aiyar, Superintendent, and Published by B. N. Sastri, M.Sc., A.I.C., A.I.I.Sc., for the "Current Science" Board of Editors, Indian Institute of Science, Hebbal Post, Bangalore.

SUPPLEMENT TO "CURRENT SCIENCE".

Reviews.

THE THEORY OF UNEMPLOYMENT. By A. C. Pigou, M.A. (Macmillan & Co. 1933. Pp. 319.) Price 15*s*. net.

In a brief study of the problem of unemployment published in the Home University Library Series about two decades ago, Professor Pigou had examined the broad economic factors which govern the causation of unemployment, and discussed its remedies and palliatives. His main conclusions were firstly, that even in a stationary industrial state unemployment would be a necessary result, if the wage-rate, instead of being left to be adjusted by the free play of economic forces, is forced up either by collective bargaining through Trade Unions, or by humanitarian or legal compulsion in favour of a minimum wage; and secondly, that in the non-stationary conditions of real life, the rigidity of the wage-rate, the impediments to the nobility of labour, and the fluctuations in the demand for labour operate as additional causes for the production of unemployment.

The present volume deals with the same problem in a much more thorough and scientific manner, with a definite aim at such completeness as can be attained in the present stage of knowledge, and with all the precision and careful analysis which students of economic science have learnt to associate with the name of Professor Pigou. The various types of causes and economic situations relevant to the amount of unemployment are here systematically classified and listed, and in the investigation of each the analysis is sought to be pressed to the farthest feasible point. This new book must therefore be welcomed, not only for its great disciplinary value to the advanced student, but as a classic achievement which extends considerably the limits of economic analysis, and furnishes a basis and a scaffolding for future work.

It is also a matter for congratulation that Prof. Pigou has definitely decided in this new book to adopt mathematical analysis as the avowed instrument of economic investigation; indeed considering the nature of the subject-matter and the intricacy of the analysis, any decision to the contrary would have been inconceivable. Prof. Marshall, the predecessor of Prof. Pigou in the Cambridge Chair, in his *Principles of Economics*—and we may add, Prof. Pigou himself in his *Economics of Welfare*—created the fashion of dressing up private mathematical reasoning into elaborate non-mathematical language for the edification of the public. The clear advantage in discarding this pretence ("Cotton-wool", as the author aptly terms it in the Introduction) is that the certitude and clarity in the mind of the writer is communicated directly and without hindrance to the reader. One recalls in this connection the controversies about the applicability of mathematical reasoning to economics, in the early days when economic concepts were in the nebulous formative stage—controversies all the more violent as both the protagonists and the opponents often suffered from fundamental misconceptions. It was doubtless the desire to avoid such misconceptions that must have led Marshall to give the advice "to burn all mathematics" in his private correspondence, and must have been partially responsible for the suppression of the mathematical element in his work. However, this phase of economic science belongs definitely to the past. To-day the term 'mathematical economics' is a misnomer; there is, on the other hand, only one economic science, and mathematical analysis is the essential and irreplacable instrument of its reasoning and method. What in fact would remain of modern economics if demanded of the ideas of its great creators, Jevons, Cournot, Walras, Pareto—ideas, economic indeed in their content and significance, but mathematical in their form? The fact that most Indian Universities (who are generally content to stay, at a modest estimate, about fifty years behind time) have declared in favour of 'non-mathematical' economics, does not render it any the less true that economic science loosened from the ballast of mathematical reasoning, becomes degraded into vague statements, referring to the qualitative interdependence of various loosely defined economic entities, and leading nowhere in particular.

The book is divided into five parts of